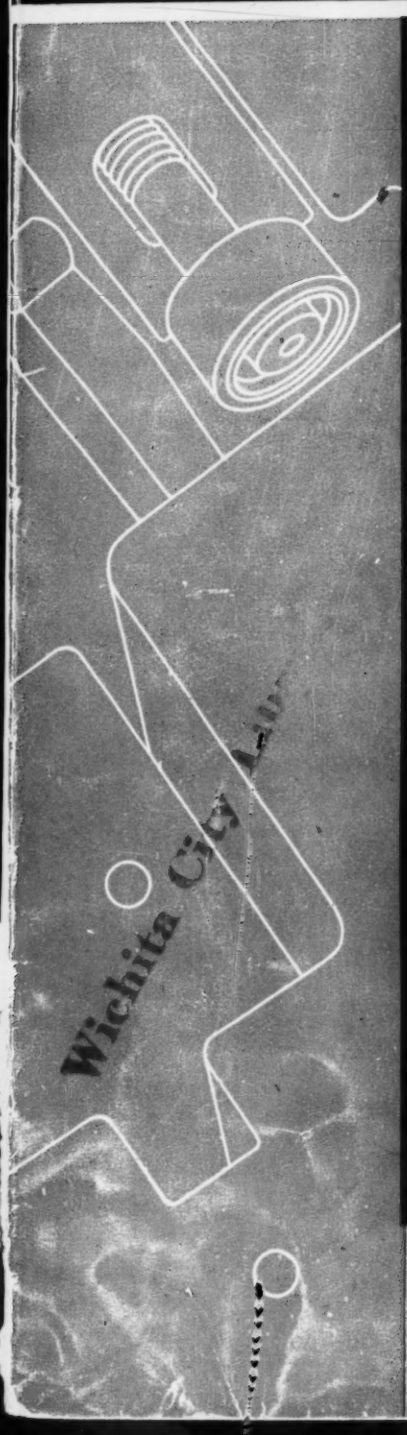
July-47

MACHINE DESIGN

July 1947



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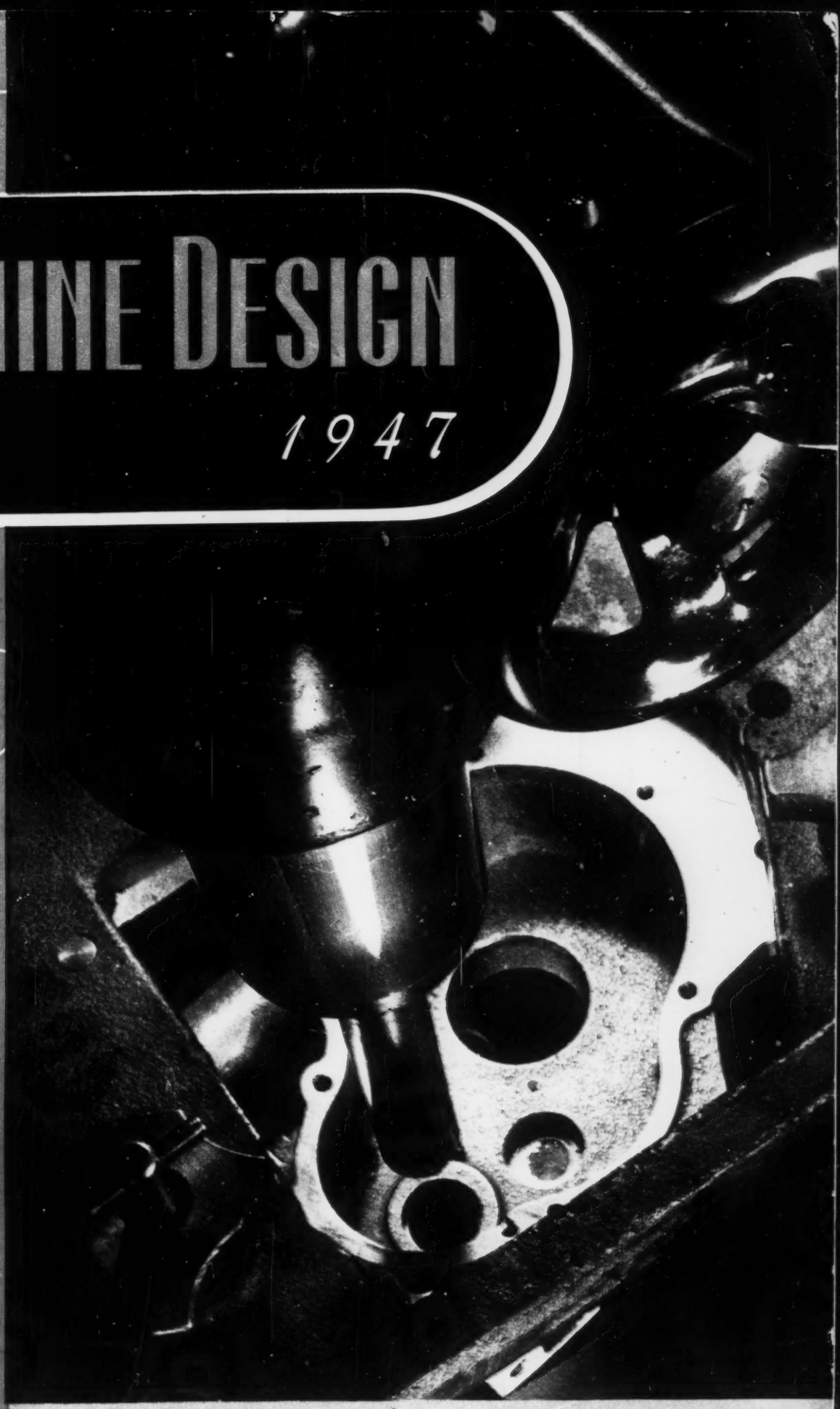

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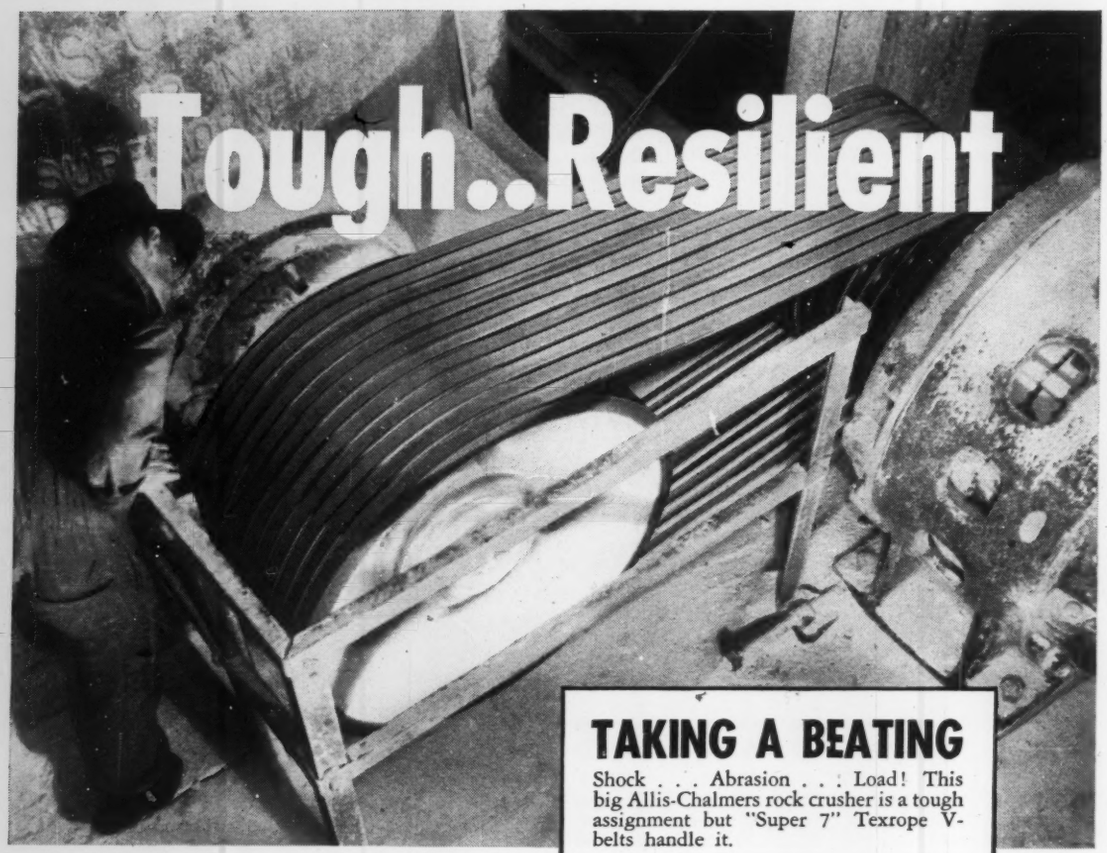
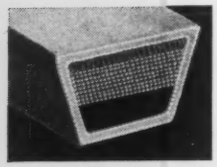
HYDROSTATIC LUBRICATION . . . HYDRAULIC SERVOS



TAKING A BEATING

Shock . . . Abrasion . . . Load! This big Allis-Chalmers rock crusher is a tough assignment but "Super 7" Texrope V-belts handle it.



. . . You get 7 Great Features in "Super 7" Texrope V-Belts

1. TOUGHER COVER. Two layers of tightly woven long-staple cotton fabric and tough, wear-resistant rubber compound. Protects the belt carcass from grit, moisture and wear — holds its shape — assures maximum belt life.

2. SHOCK ABSORBING. "Super 7" belts combine great strength with the degree of resiliency necessary for long life and smooth power transmission.

3. HEAT RESISTING. *All* "Super 7" V-belts are designed and built to give high resistance to heat.

4. STRONGER CORDS. More cords—imbedded in cool-running rubber compound. A powerful load-carrying structure.

5. PRECISION CURED in pressure molds to assure accurate section and perfect bonding of cords, cover and cushion.

6. ACCURATELY MATCHED. Every belt weighed, measured and carefully inspected before being sized and packed.

7. ENGINEERING LEADERSHIP. "Super 7" Texrope V-belts represent 22 years of research and experience — by Allis-Chalmers, originator of the Multiple V-belt drive.

"Super 7" Texrope V-belts come in five types to meet every operating requirement: *Standard — Heat Resisting — Oil Resisting — Oil Proof* and *Static Resisting*. Call your Allis-Chalmers office or dealer. ALLIS-CHALMERS, MILWAUKEE 1, WISCONSIN.

A 2238

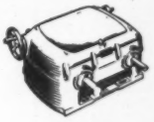
Refer to Sweet's Catalog.

TEXROPE .. Greatest Name in V-Belt Drives

"Super 7" V-BELTS
Five Types — Sizes to suit every power transmission job.

Texsteel, Texdrive, "Magic-Grip"
— sheaves in a full range of sizes, grooves.

"Vari-Pitch" SHEAVES
Exact variations in speed, stationary or motion control.



SPEED CHANGERS
Speed variations up to 375% at the turn of a crank.

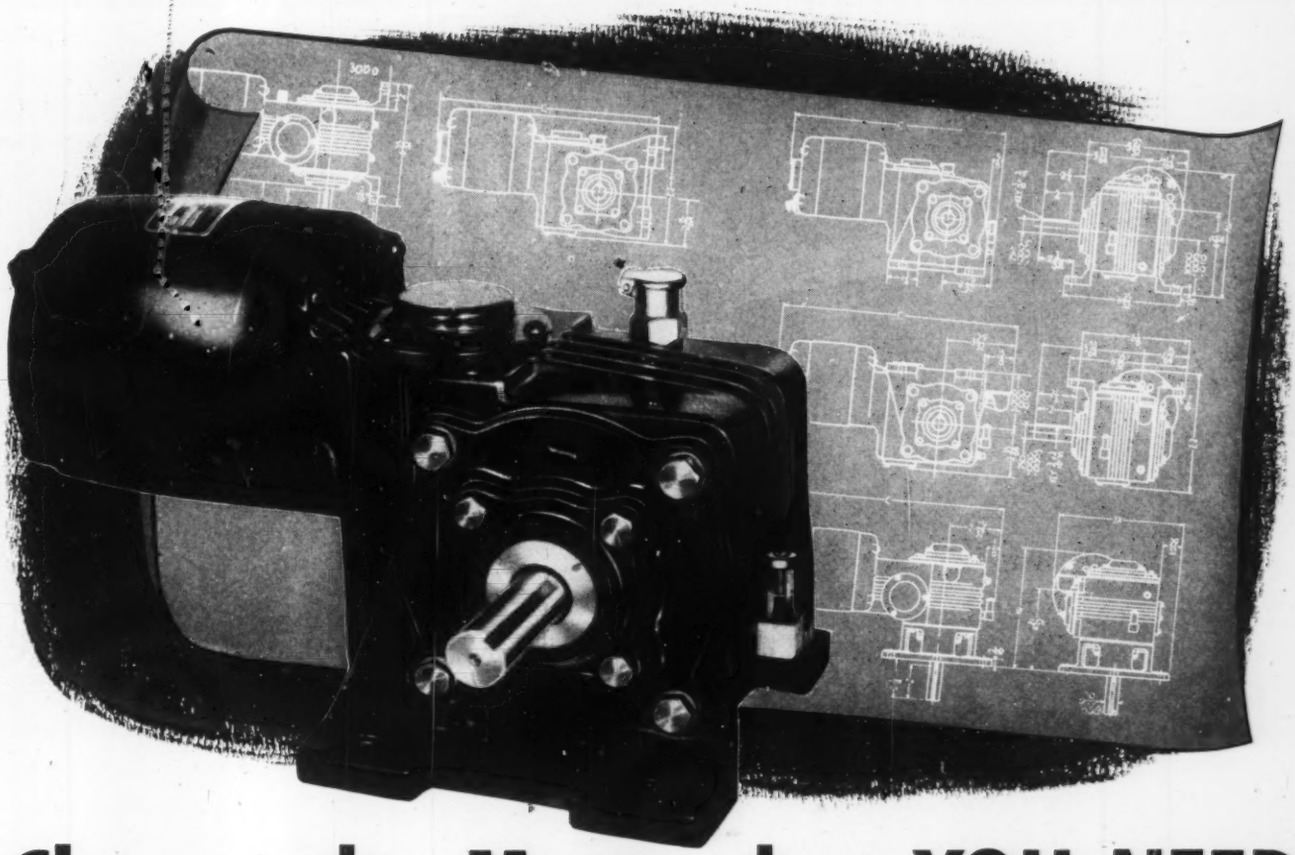
ENGINEERING
Finest V-Belt engineering talent in the world—at your call.

TEXROPE "Super 7" V-Belts result from the cooperative research of two great companies — Allis-Chalmers and B. F. Goodrich. They are sold only by A-C.

ALLIS-CHALMERS

One of the Big 3 in Electric Power Equipment — Biggest of All in Range of Industrial Products

1847 1947
A CENTURY OF SERVICE to Industry THAT MADE America Great



Choose the Motor that YOU NEED

Selection of the right motor for the operation of your device requires careful consideration of the operating characteristics of your machine. Speed, torque, ambient temperature, and other characteristics will dictate the motor to be used, as well as probable maintenance, space available, appearance, and many other important factors.

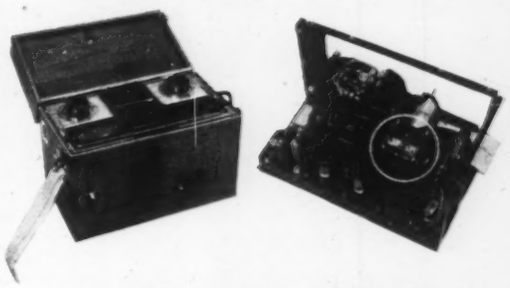
Bodine Has 3000 Types

Over 3000 standard sizes and specifications make it easy for Bodine application engineers to provide the right motor to operate your machine. These motors are available either with or without integral speed-reducers chosen according to your requirements.

Long Proven Life

Bodine motor applications in all types of service have long ago proven the reliability of these motors. Consult Bodine engineers when planning your machine, so that full consideration can be given to proper choice of the motor. Bodine Electric Co., 2258 West Ohio Street, Chicago 12, Illinois.

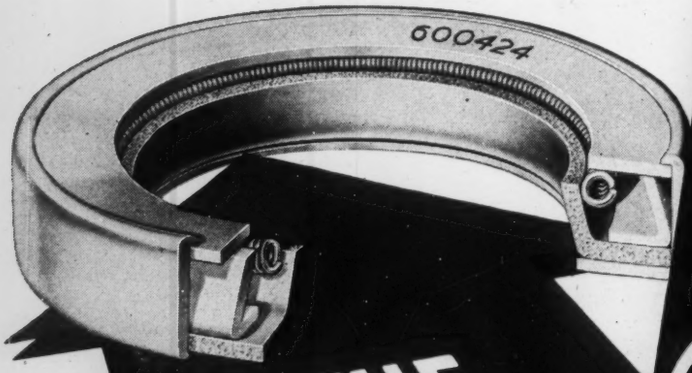
TYPICAL APPLICATION



SANBORN VISO-CARDIETTE

An example of the choice of Bodine motors for important applications is the use of a Type K speed reducer motor in the electrocardiograph manufactured by the Sanborn Company. The records provided by this machine are used for diagnosis and must, therefore, be accurate, dependable, and clear.

BODINE FRACTIONAL HORSEPOWER MOTORS



Of First Importance

THE PACKING ELEMENT

PERFECT Oil Seals

PATENTED

The Sirvis Leather packing member of the "Perfect" Oil Seal is impervious to mineral oils, greases and moisture. It is preformed and plastically treated, resists heat, exerts no wick action to draw lubricant from the bearing, does not disintegrate in service and is self-lubricating. Sirvis Leather is uniform in physical properties and is processed to accurate specifications. It is not a scarce material—supplies are and will remain entirely adequate for your needs.

"Perfect" Oil Seals are also available with Sirvene Synthetic Rubber packing elements. Sirvene is the time-tested elastomer for shaft sealing under specific operating conditions which are not compatible with the physical properties of leather.

Get the experienced judgment of Chicago Rawhide engineers on your sealing problem.

2710

MACHINE DESIGN

THE PROFESSIONAL JOURNAL OF CHIEF ENGINEERS AND DESIGNERS

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This Month's Cover: Boring a blind hole in a radar drive-gear housing. Quantity production to extremely close tolerances is obtained on this Moore jig borer. Production boring to precision limits is discussed in the article on Page 137.

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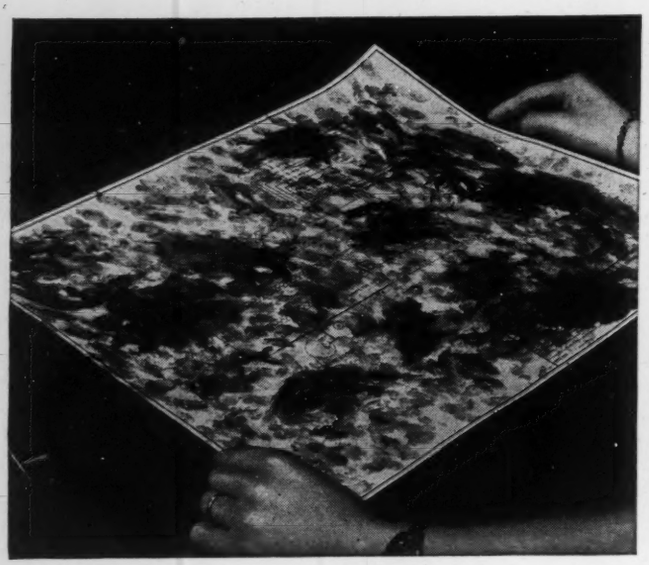
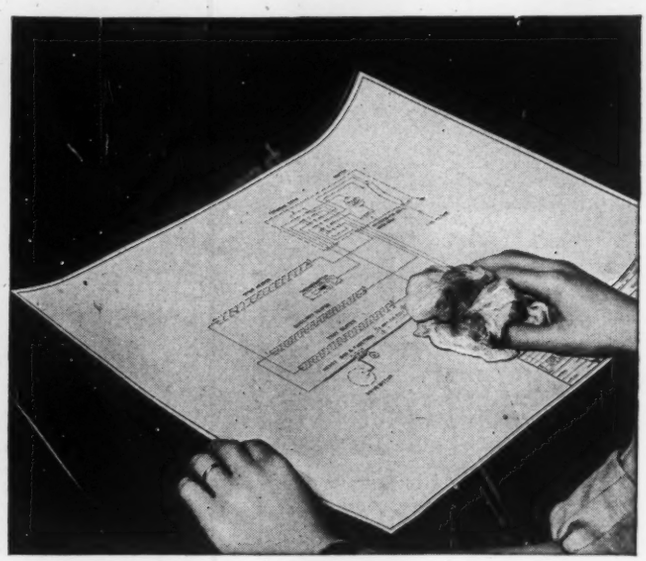
The worst "beating" any print ever took!



Immersed in water for 72 hours! Then oil was poured over it... and, just before this picture was taken, it was smeared with heavy grease!



Here is the same Ozaplastic print seconds later! ... As good as ever, simply cleaned with a damp cloth!

OZAPLASTIC eliminates 95% of your print replacement costs . . . is recommended whenever the going is tough ...where standard paper or cloth prints "fold up" after a short period of service.

You'll want to use Ozaplastic in the shop and field ... around operations where grease, grime, or water abound ... where precision is of the utmost importance ... where annoyances—such as having to wait for a new print—put a hitch in production.

When soiled, you need only rub a damp cloth over Ozaplastic and it's like new—all details sharp and clear, *jet black* on a glossy white background.

For this reason, OZAPLASTIC is also used in sales catalogs and presentation booklets—even laminated on machines, etc., when "on-the-spot" instructions or wiring diagrams are required.

Now . . . Make 16 Types of Ozalid Prints!

OZAPLASTIC is only one of the 16 different types of prints you can produce in an Ozalid machine.

For example, you can reproduce the lines and images of any translucent original in black, blue, red, sepia, or yellow colors. And make prints on white or tinted paper, cloth, foil, film, or plastic.

Thus, you can "color code" prints of different operations . . . and always match the print to the job at hand.

Furthermore, all of these Ozalid prints are made in exactly the same manner—without interruption—in 30 seconds or less.

See the 16 different types of Ozalid prints. Learn how economical it is to make them in the new OZALID STREAMLINER.

Write today for free booklet No. 276.

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DIVISION OF GENERAL ANILINE AND FILM CORPORATION

JOHNSON CITY, NEW YORK

Ozalid in Canada—Hughes Owens Co., Ltd., Montreal

Early deliveries
with or without built-in motor

1 All speeds — top to zero.
2 Close speed-holding over a wide range.
3 Extreme compactness.
4 Rapid reversal where wanted without stopping motor.
5 Multiplied torque at low speeds.
6 Accurate return to pre-set speed.

★ ONLY **Graham** gives you all 6 features—in a variable speed drive

★ at a price that keeps your machine competitive!

Now the machine you build can have all the advantages of a full speed range — from top to zero (plus reverse where wanted)—and still be sold competitively. Graham prices have been reduced more than half by simplified design and volume-production economies. Some models are priced as low as $50 (without motor.) That means you can apply the full advantages of Graham variable speed drive to low-power machines such as small tools, office machines, pumps, cutting torches, etc. — *and still remain competitive as to price!*

Graham is the only variable speed drive built as a straight line extension of a standard induction motor. It is a model of compactness, requiring no more fastenings than a single-speed motor. Model 40 (for ¼ to ¾ HP motors) and Model 15 (up to ⅛ HP) are available with or without motors — see tables below — or with built-in parallel shaft or right-angle gear units, reductions, or step-ups; with speeds down to zero and a moderate reverse, or equal speeds both sides of zero. Wide choice of controls; direct or remote, includes: manual, micrometer, lever, switch, or selsyn types, or combinations according to requirements.

Graham performance is proved by 8 years of success as standard equipment on leading machines. For complete information, write us for Bulletin 509, with prices and delivery.

GRAHAM TRANSMISSIONS, INC.
3754 N. Holton Street • Milwaukee 12, Wisconsin

For Coupled Motor or Offset Drive.

•

With built-in motor. *Note that the built-in motor is especially designed to form an integral streamlined part of the drive.*

•

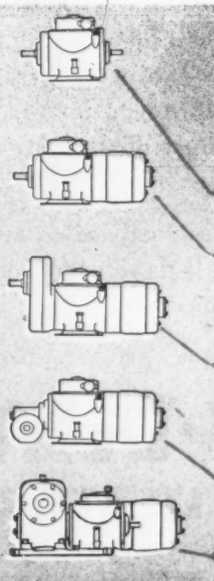
With built-in motor and built-in spur reduction or step-up.

•

With built-in motor and built-in worm reduction, Model 15. *Output shaft may extend horizontally to either side, or vertically up or down. Additional ratios available—6:1, 10:1, 15:1, 30:1, and 60:1.*

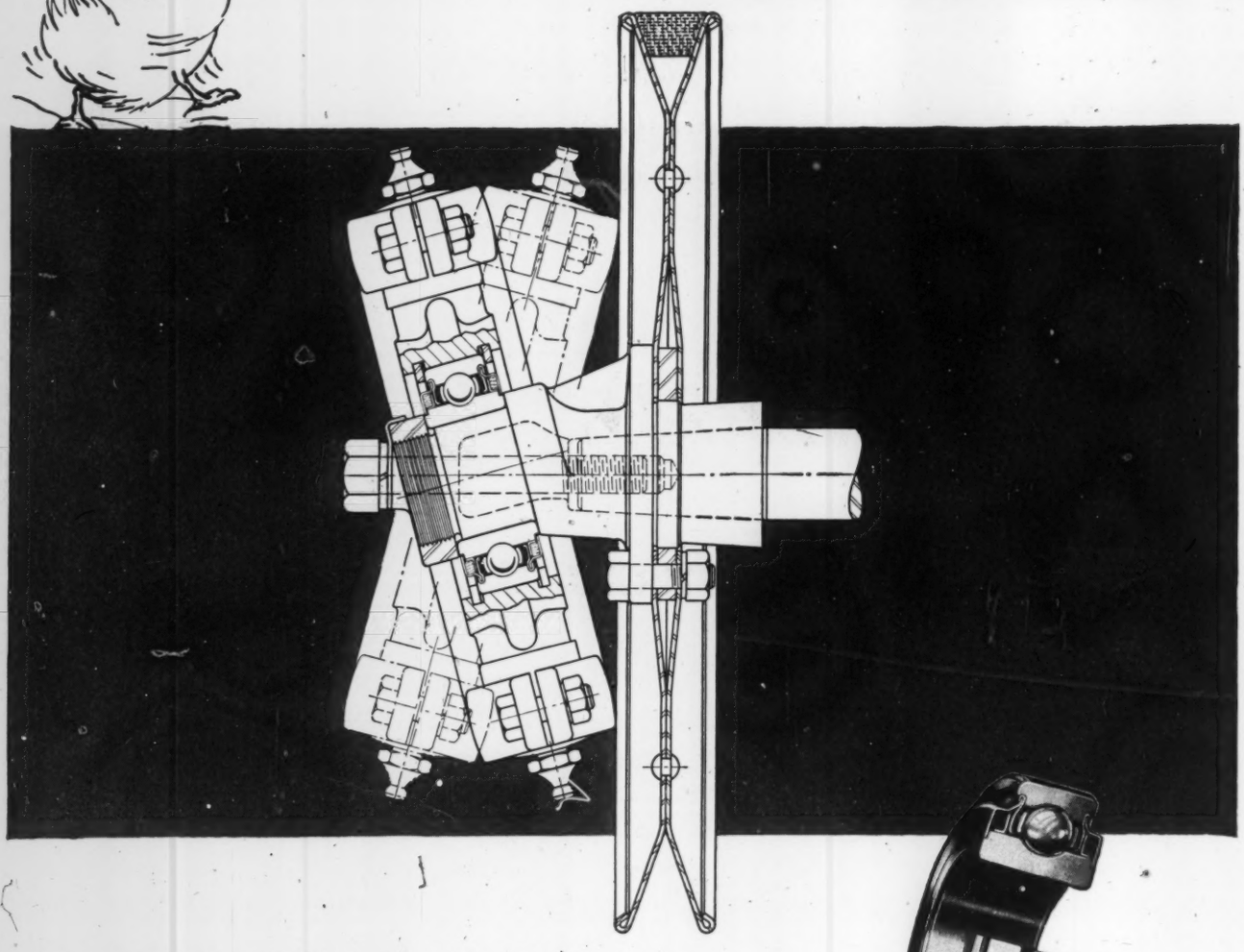
•

With built-in motor and built-in worm reduction, Model 40. *Output shaft extends both sides horizontally or vertically up or down. Additional ratios available — 9:1, 12:1, 18:1, 36:1 and 47:1.*



Model	Input Speed	Output Speed Range	In Lbs. Torque Rating		Approx. Ins. Overall Dimensions			Motor H.P.
			At Max. Speed	At Min. Speed	Lgth. incl. shaft ext.	Width	Height	
15	3600	1100/0	3.5	7.5	8¼	4⅝	5⅜	1/15 to ⅛
40	3600	1100/0	30	60	14½	7	8	¼ to ¾
15M	3600	1100/0	3.5	7.5	11½	4⅝	5⅜	1/15 to ⅛
40M	3600	1100/0	30	60	19½	7	8	¼ to ¾
15MR5	3600	220/0	15	35	13	4⅝	6¾	1/15 to ⅛
40MR5	3600	220/0	140	280	22	7	10	¼ to ¾
40MR2.8	3600	400/0	80	160	22	7	10	¼ to ¾
15MS2.5	3600	2750/0	1.3	2.8	13	4⅝	6¾	1/15 to ⅛
40MS2.8	3600	3100/0	10	20	22	7	10	¼ to ¾
15MW20	3600	55/0	35	75	12¾	4⅝	5⅜	1/15 to ⅛
15MW40	3600	28/0	60	120	12¾	4⅝	5⅜	1/15 to ⅛
40MW6	3600	190/0	120	250	24	8½	10½	¼ to ¾
40MW24	3600	46/0	420	840	24	8½	10½	¼ to ¾
40MW60	3600	19/0	800	1700	24	8½	10½	¼ to ¾

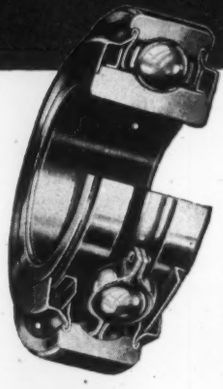
. . . THE ALWAYS WILLING WOBBLER



THIS BEARING MOUNTING gives a "wobble plate" action which is translated into oscillating motion for the sickle drive in a combine Harvester.

Such action demands a bearing that can take misaligning or thrust loads from either direction — yet will operate with minimum friction, will require no adjustment for wear. In short—a bearing that can keep a working wobbler *always willing*.

That, in a nutshell, is the New Departure self-sealed and lubricated-for-life ball bearing. It meets all these conditions squarely, and it never needs attention of *any kind* during its long life.



● New Departure self-sealed, lubricated-for-life ball bearings not only simplify design, need fewer mounting parts, but they pay dividends to the machine *user* as well. They don't take up a minute of his time. They are "built to be forgotten."

8469-C

NEW·DEPARTURE
BALL BEARINGS

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONN. • Branches in DETROIT • CHICAGO • LOS ANGELES and other cities

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HERE'S A BETTER WAY TO TURN IT..,

You're following the example of leading manufacturers when you put Delco motors to work turning any type of appliance shaft. What makes Delco motors preferred? Their quietness and smoothness, their compactness and efficiency . . . and their specialized engineering, developed through Delco Products' years of cooperation with the appliance industry. Refrigerators, washers, ironers, stokers, oil burners, air conditioners . . . Delco motors, engineered to meet specific torque and service requirements, do a better job of shaft-turning for *all* appliances. Sizes: ⅛ h.p. to 50 h.p. Delco Products Division, General Motors Corporation, Dayton, Ohio.

OILGEAR

See

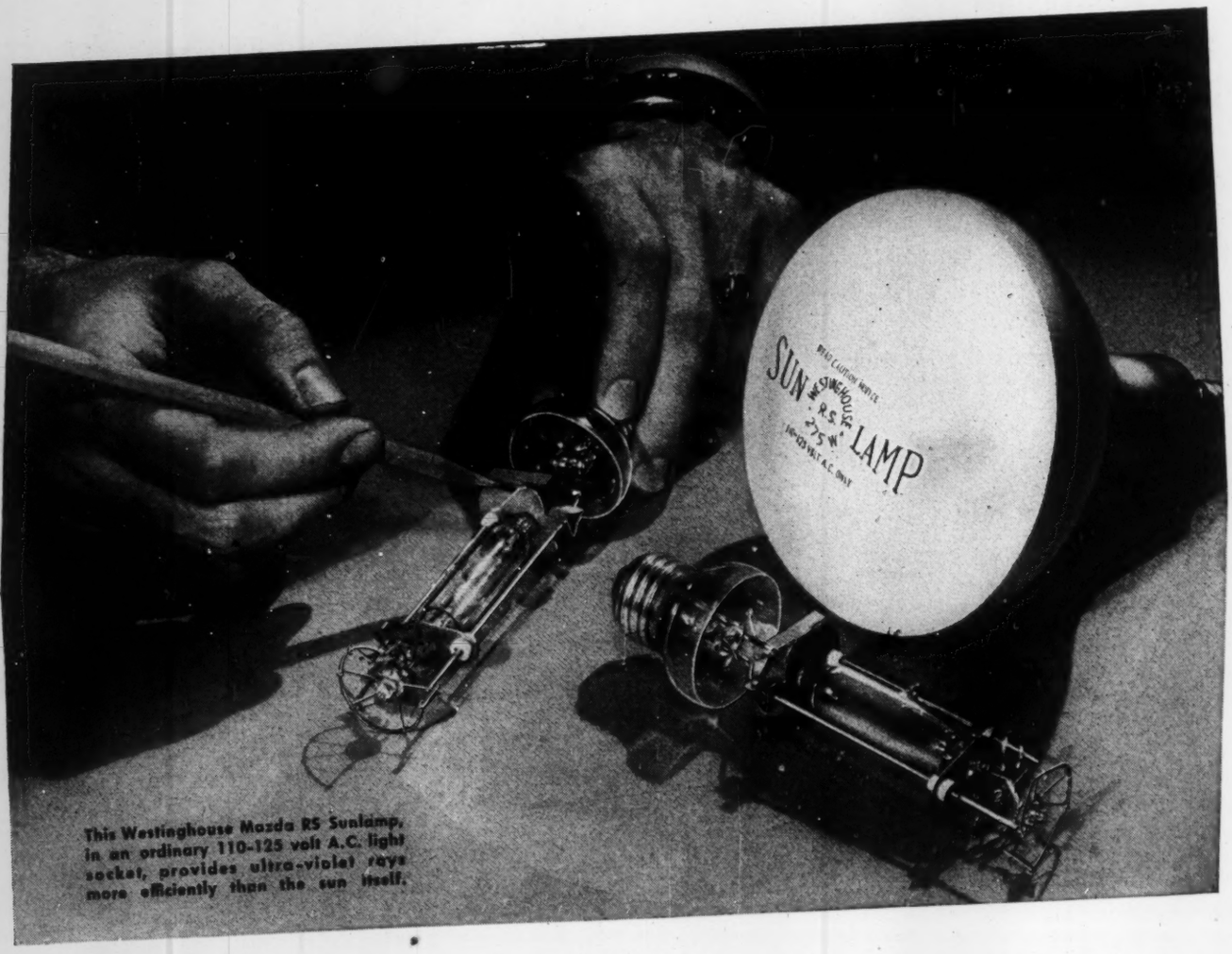
THIS FEED PUMP IN ACTION AT THE MACHINE TOOL SHOW,

Sept. 17-26

The new small Oilgear Feed Pump Type "JK" will be exhibited at the Machine Tool Show, Dodge Chicago plant, September 17-26. It will be mounted on a reservoir base, direct-connected to a 1½ h.p. 1200 R.P.M. electric motor, piped to a double-acting cylinder and will demonstrate manually, semi-automatically and automatically controlled machine tool cycles. Be sure to see it.

Oilgear Fluid Power

A new light on sunlight



This Westinghouse Mazda RS Sunlamp, in an ordinary 110-125 volt A.C. light socket, provides ultra-violet rays more efficiently than the sun itself.

How 3 metals helped beat the sun at its best

They wanted July sunshine from a single bulb . . . any time of year . . . at a click of a switch. Just screw it into a socket like an ordinary light bulb. No special transformers . . . no special fixtures.

Westinghouse engineers were sure it could be done. So, they designed a small quartz mercury vapor tube . . . placed it inside a bulb . . . and supported it there between two flat spring parts which cushion it top and bottom.

Then they ran into metal problems.

What metal would remain a spring with operating temperatures running up to 750° F.? How could any spring survive 932° F. while the bulb was being evacuated? Red-hot springs soon go limp.

After much experimenting, Westinghouse engineers hit upon a metal that seemed custom-fitted to their needs: "Z"* NICKEL. It's an age-hardenable nickel made especially for applications where a metal with high spring properties is needed to withstand destructive temperatures and corrosive conditions.

Test after test proved that the little "Z" Nickel springs keep their grip on the quartz tube in spite of the heat, and cushion it against damage by bumps for the life of the lamp.

The next two problems were just as easy with INCO Nickel Alloys. For the inside conductors, flexible 38-strand "A"* Nickel wire provided the electrical conductivity and heat-resistance. For the sturdy little structural frame which holds the whole assembly together, "D"* Nickel provided the necessary hot-strength.

Result: *a long-lasting bulb, says Westinghouse, that sun tans more efficiently than the sun itself.*

* * *

What's your metal problem? If it's high temperatures, strength, ductility . . . or a combination of these . . . send for "Engineering Properties of Nickel." Or investigate the other tough, corrosion-resistant INCO Nickel Alloys, and you'll probably find exactly what you need. Full technical information and assistance are yours at any time.

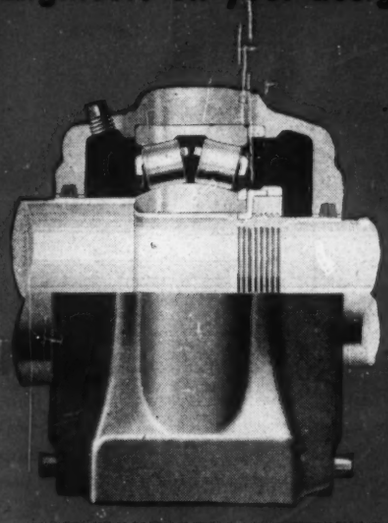
*Reg. U.S. Pat. Off.

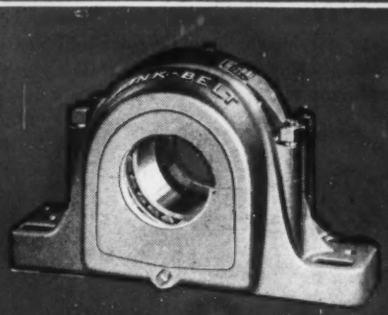
THE INTERNATIONAL NICKEL COMPANY, INC. • 67 Wall Street, New York 5, N.Y.

EMBLEM OF SERVICE

NICKEL INCO ALLOYS

To claim long life—to claim efficiency—to claim accuracy for Link-Belt Ball and Roller Bearings is merely to accent the obvious. More interesting to you is the completeness of Link-Belt's Ball and Roller Bearing line—mounted and unmounted. Still more interesting is the nation-wide organization of expert Link-Belt Bearing Engineers, whose sole service to Link-Belt rests *in their service to you.* Use our books (No. 2094 and 2095 sent immediately upon request)... but use also the expert knowledge of our Bearing Engineers on your design problems.





1 Heavy series precision-built double row self-aligning roller bearings.

2 Inner ring directly mounted on precision turned or ground shafting assures greatest accuracy.

3 Locknut clamps assembly securely to shaft and is prevented from loosening by serrated lock washer.

4 Felt seals for grease lubrication or "Spiro-Seals" for oil or grease lubrication.

5 True flat surfaces assured for nut pressure surface.

6 Housings drilled and tapped for drain plugs on both sides.

7 Casting spotted for dowel holes to locate unit on support. Slotted holes for foundation bolts.

8 Sturdy, compact, split housing provides convenience in mounting, lubrication and disassembly.

9 Tapped holes in cap take standard screw to raise cap off base without damage to finished surface.

10 Permits different methods of lubrication, such as grease, constant level oil or circulating oil.

11 Bearings can be fixed or floated axially. "C" spacers may be inserted or removed as required.

LINK-BELT COMPANY

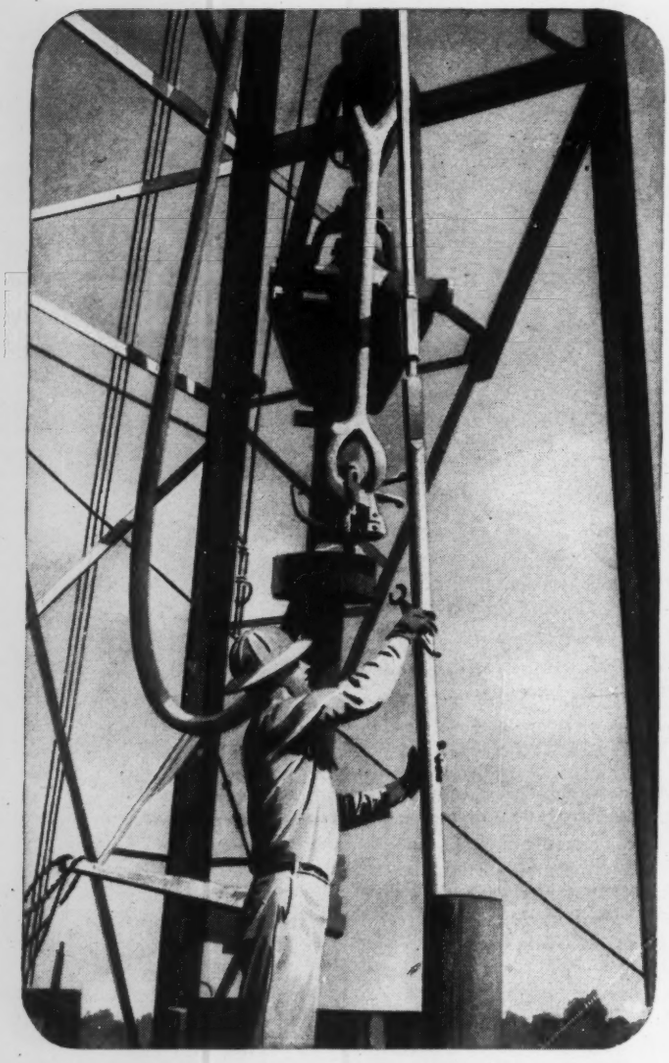
Chicago 9 • Indianapolis 6 • Philadelphia 40
Atlanta • Dallas 1 • Minneapolis 5 • San Francisco 24
Los Angeles 33 • Seattle 4 • Toronto 8 • Offices, Factory Branch Stores and Distributors in Principal Cities

LINK-BELT

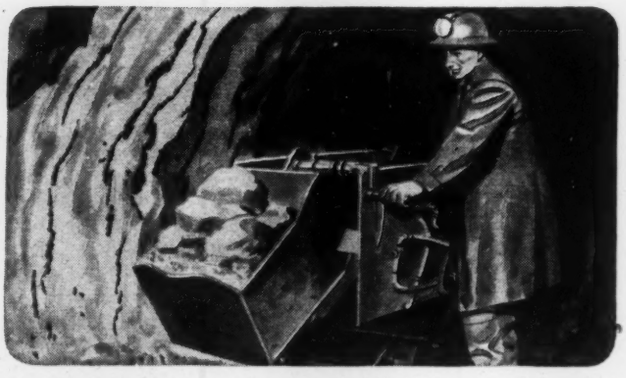
THE SYMBOL OF QUALITY — LB — LINK-BELT

BALL AND ROLLER BEARINGS

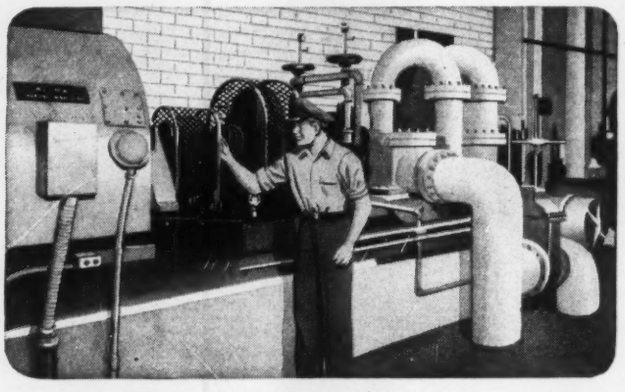
Watch industry Fluid-Drive* ahead!



1 Oil Drilling. There's a definite trend in the derrick forests of the oil country: It's to Diesel engines and Gyrol Fluid Drive for drill rigs. Loads are taken up smoothly without inordinate strain. Naturally, equipment lasts longer and there is less time lost for repairs.



2 Mining. Looking for tough jobs? Step underground where overloads, excessive starting and stopping, and operator abuse are common practice. Gyrol Fluid Drive provides smoother operation, protects valuable equipment under this rugged use—stretches its life.



3 Power Plants. Valuable for boiler feed pumps is the adjustable speed control of Gyrol Fluid Drive. Wasteful throttling at feed water regulator valve is eliminated. Life of both pump and piping is increased by the use of lower pressures. Boiler efficiency is improved.

4 You? Over 7½ million horsepower (exclusive of automobiles) are driven through Gyrol Fluid Drive. This is *only the beginning!* How about your job? Let's get together.

For better performance get—

AMERICAN BLOWER

DETROIT 32, MICHIGAN

In Canada: CANADIAN SIROCCO CO., LTD., Windsor, Ont.

Division of AMERICAN RADIATOR & Standard Sanitary CORPORATION

GYROL *Fluid Drive*

* *Gyrol Fluid Drive is a product pioneered and developed for American industry by American Blower. It is designed for applications where smooth transmission of power or stepless adjustable speed control is desired. Looking beyond the long list of applications already developed, we should like to work with you to find new ways to "Fluid-Drive Ahead!"*

Now! YOURS FOR BETTER PERFORMANCE!

Centrifugally Cast BUSHING STOCK

By Shenango-Penn

ASK FOR FREE BULLETIN No. 145

It contains additional data, including complete list of stock sizes, diameters and weights of Shenango-Penn machined centrifugally cast tubular bars and chill-cast solid bars . . . all available for immediate shipment.

IF you use bushing stock, why not get, at prevailing prices, the best that money can buy?

The same centrifugal casting techniques that make Shenango-Penn a preferred source of supply for long-lived, made-to-order bearings, bushings, sleeves, liners, rolls, etc., are now offered in Shenango-Penn tubular bushing stock!

Thus you gain many advantages: finer, pressure-dense grain, an 8 to 20% increase in tensile, finely divided and uniform lead dispersion, superior wear resistance, as much as 30% greater elongation, and *positive* relief from sand inclusions or blow holes. Here's bushing stock that's ready now to give you a big extra margin of safety, service-life and over-all economy.

Send for free descriptive bulletin No. 145 and the address of the Shenango-Penn sales office nearest you.

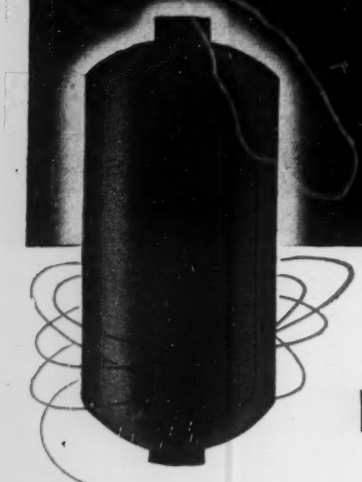
SHENANGO-PENN MOLD COMPANY

1268 West Third Street • Dover, Ohio

EXECUTIVE OFFICES • PITTSBURGH, PA.

SHENANGO-PENN

ALL BRONZES • MONEL METAL • ALLOY IRONS



HERE'S SOMETHING YOU SHOULD KNOW ABOUT DYED FIBERGLAS YARNS

Fiberglas*, in its many forms, is helping designers and manufacturers solve many problems which no other single material can solve.

For example, Fiberglas Yarns are now being dyed blue, red, green, yellow, brown, orange, slate, purple and black for many uses. Dyed Fiberglas Yarns are used as marker yarns in rubber-covered wire, nonmetallic sheathed cable, flexible cord and fixture wire. They are used as circuit tracers in radio hookup wire and aircraft cable.

Dyed Fiberglas Yarns have high tensile strength, small diameter and do not form gas pockets under high-temperature extruding conditions. They are resistant to heat, moisture and fungi as well as to chloroform, carbon tetrachloride, Stoddard Solvent and Toluene.

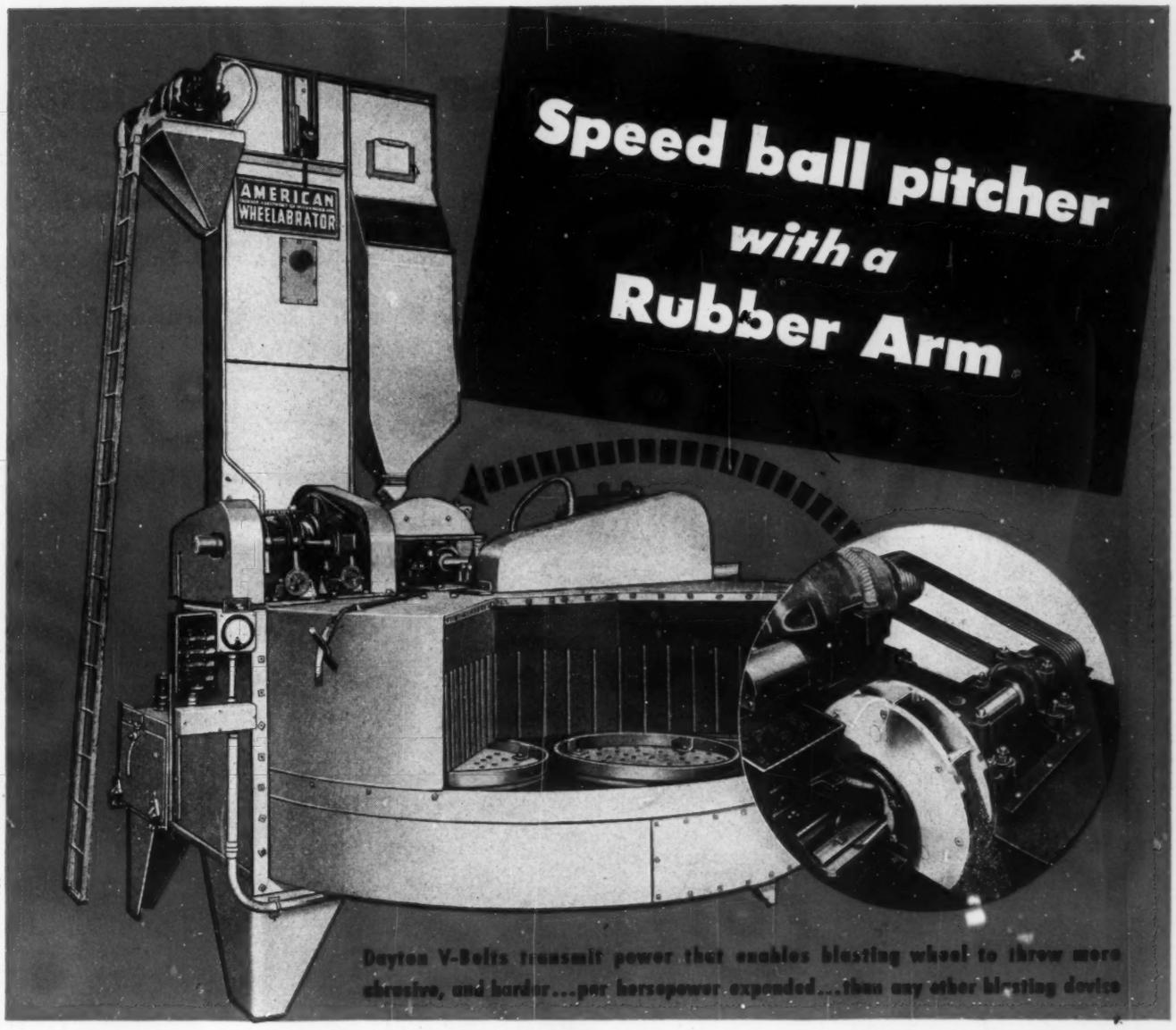
These yarns may be the solution to some of your design problems other than their use in wire and cable. Fiberglas technicians will be glad to co-operate with you. Write for complete information. Owens-Corning Fiberglas Corporation, Dept. 808, Nicholas Building, Toledo 1, Ohio. Branches in principal cities.

In Canada: Fiberglas Canada Ltd., Toronto, Ontario

***Fiberglas is the trade mark (Reg. U. S. Pat. Off.) of a variety of products made of or with glass fibers by Owens-Corning Fiberglas Corporation.**

OWENS-CORNING FIBERGLAS *Yarns*

TM. REG. U.S. PAT. OFF.



The need for transmitting great horsepower in a small space was the problem facing the industrial designer of an abrasive blaster. And a Dayton V-Belt Drive solved it.

This is another outstanding example of the flexibility of Dayton V-Belt Drives. And the ability of Dayton V-Belts to perform in excess of standard requirements under all operating conditions . . . unaffected by dust, oil, heat, liquids . . . is another of the many reasons why more industrial designers consistently specify Daytons for original equipment.

No matter what type machine you design, or what size it is, Dayton V-Belts will transmit power to it more efficiently, more economically.

Remember, a Dayton Power Transmission Specialist is always ready to help you . . .

DAYTON RUBBER • DAYTON, OHIO

NOW! *Rayon Cords

PROVIDE DAYTON V-BELTS WITH

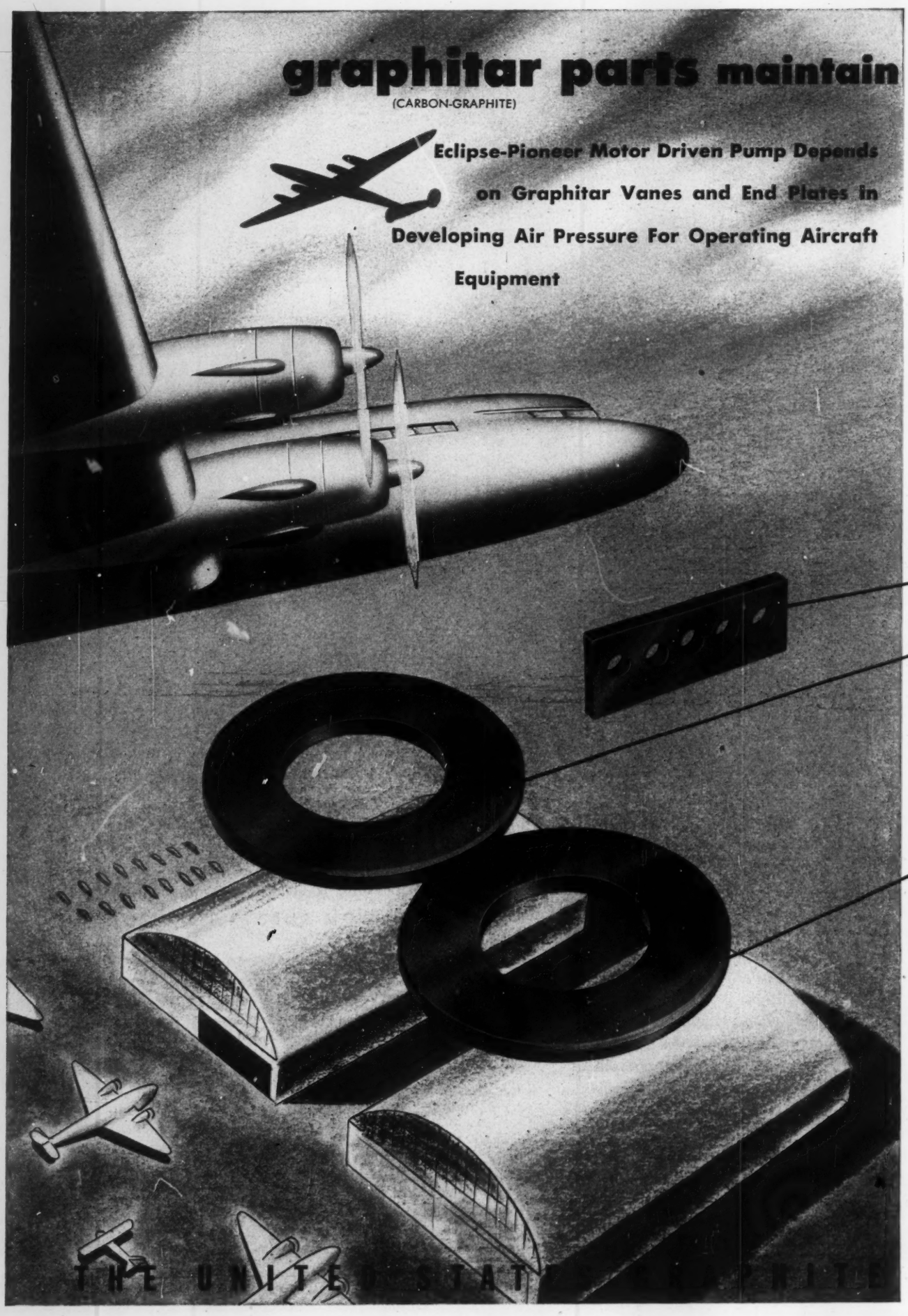
1. Minimum Stretch 2. Greater Flex Strength 3. Longer V-Belt Life

* Rayon cords are *specially processed* by Dayton for use in V-Belts to provide the most efficient and economical power transmission service for your machine needs. For the complete story write for booklet A-469.

Dayton Rubber

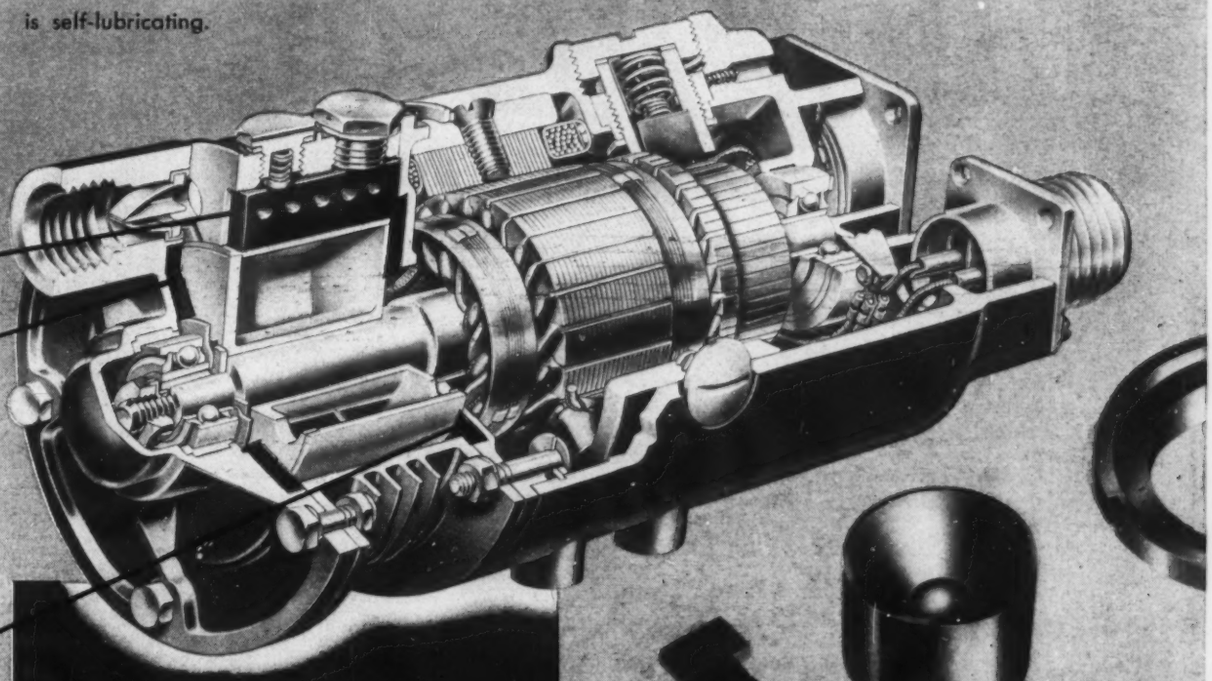
THE MARK OF TECHNICAL EXCELLENCE IN NATURAL AND SYNTHETIC RUBBER

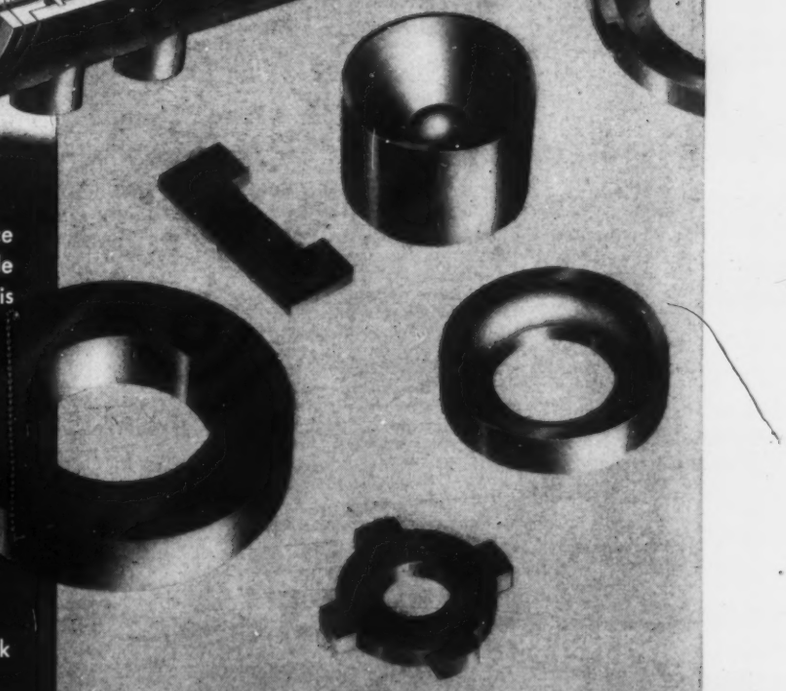
THE WORLD'S LARGEST MANUFACTURER OF V-BELTS


graphitar parts maintain
(CARBON-GRAPHITE)
Eclipse-Pioneer Motor Driven Pump Depends
on Graphitar Vanes and End Plates in
Developing Air Pressure For Operating Aircraft
Equipment

high efficiency in dry air pump

Small, dependable Graphitar parts perform vital service in the Eclipse-Pioneer Motor Driven Dry Air Pump. This pump, widely used to provide air pressure or suction for aircraft equipment, requires virtually no maintenance and absolutely no lubrication. Motor and pump are integral. The pump rotor operates at speeds up to 12,000 r.p.m. in developing pressures as high as 15 p.s.i. Graphitar vanes are held against the rotor surface by spring pressure, maintaining a sliding seal to continuously separate air inlet and outlet ports. Graphitar end plates provide an efficient air seal between the ends of the rotor and the housing. Engineers of the Eclipse-Pioneer Division of Bendix Aviation Corporation specified Graphitar at these important points, because Graphitar is highly resistant to wear and heat, it is dimensionally stable, and it is self-lubricating.





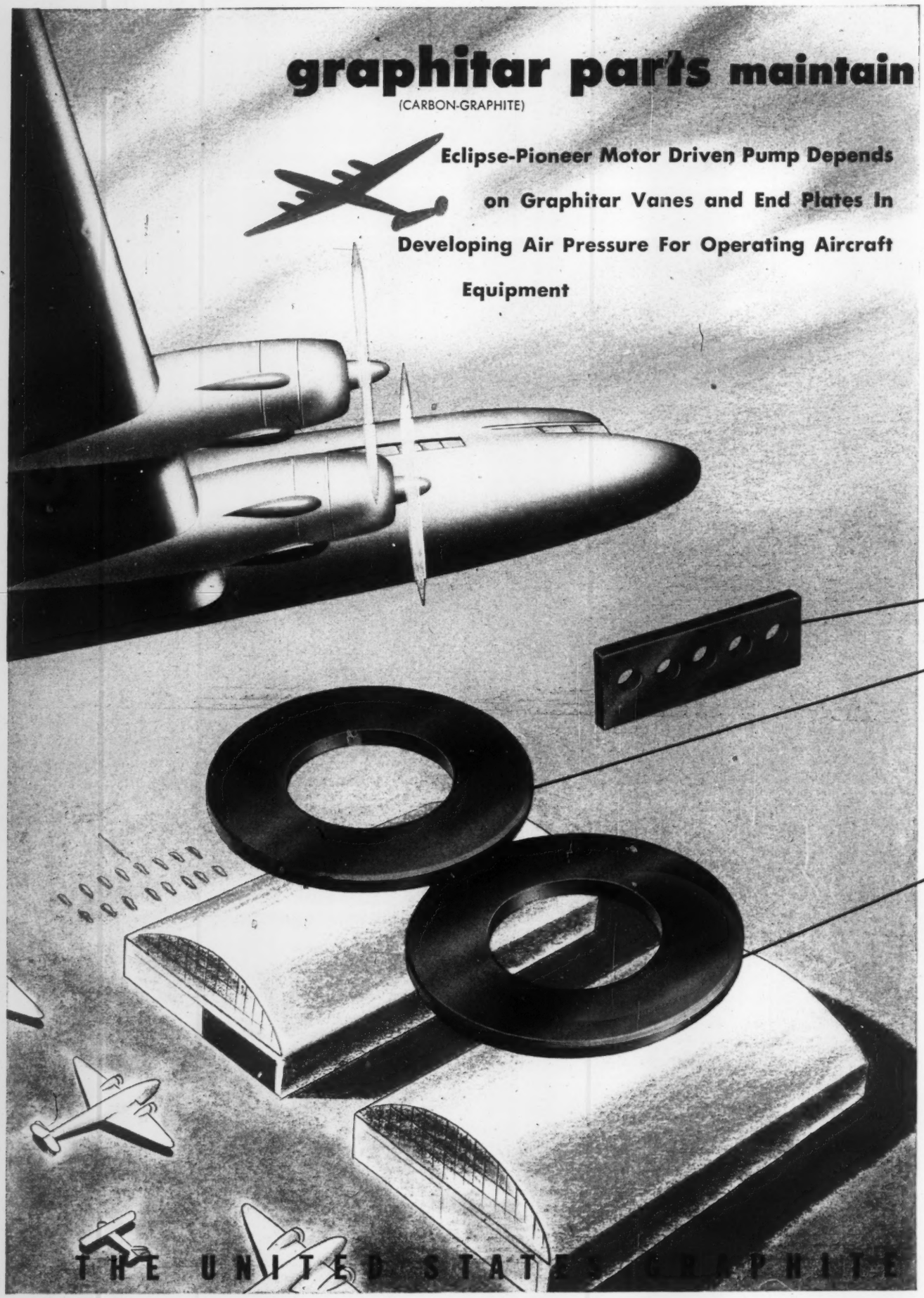
Graphitar is a carbon-graphite substance that has many unusual properties valuable to efficient mechanical performance. It is self-lubricating, and takes on a high polish under load. It is chemically inert. It will not melt or fuse. It is unaffected by temperature extremes. It is extremely light weight. We are equipped to mold Graphitar parts in a variety of shapes and can finish close-tolerance dimensions—.0005" in small sizes. Send us sketches of your products. Our engineers will show you where Graphitar may improve mechanical performance and save you money. Ask for 44-page catalog.

COMPANY, SAGINAW, MICHIGAN

graphitar parts maintain

(CARBON-GRAPHITE)

Eclipse-Pioneer Motor Driven Pump Depends on Graphitar Vanes and End Plates In Developing Air Pressure For Operating Aircraft Equipment



THE UNITED STATES CARBON GRAPHITE

high efficiency in dry air pump

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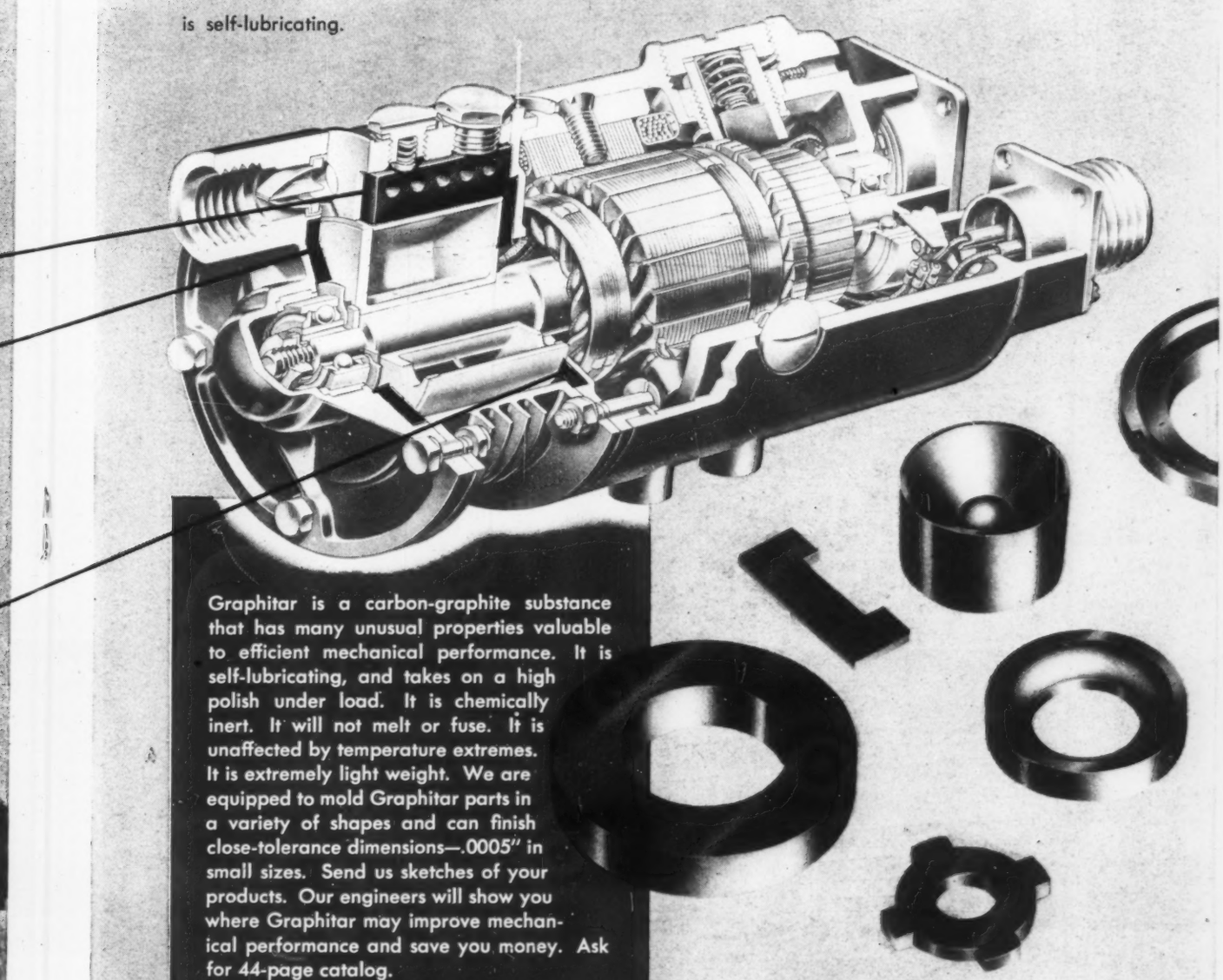

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COMPANY, SAGINAW, MICHIGAN

Two-Cylinder

SMOOTH POWER FOR EVERY NEED

THE NEW ONAN "CK" and "BH" ENGINES . . .

More and more builders of engine-driven equipment are turning to the new Onan engines for powering new products and improving their present ones. The "CK" (10 hp) and "BH" (5.5 hp) are heavy-duty, 4-cycle, air-cooled engines with the wide power range, compactness and lightweight which make them readily adaptable to hundreds of jobs.

Special models are available with gear reduction, electric starting, spring-loaded clutch and gas-gasoline carburetion. Accessories to fit the job . . . mounted fuel tanks, centrifugal clutch with pulleys, etc., can be supplied.

Let us help you solve your power application problem. Write for information and specifications.

ONAN AIR-COOLED ENGINES: CK—2-cylinder opposed, 10 hp. BH—2-cylinder opposed, 5.5 hp. COM-1B—1-cylinder, 3.25 hp.
ONAN ELECTRIC PLANTS: 350 to 35,000 watts.

Immediate delivery on early orders.

Onan PRODUCTS

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ONAN *4-Cycle* ENGINES

"Truly a Lifetime Motor" ©

Depend on B-Line®

1/6 TO 30 HP.

Added plant facilities enable us to offer special advantages in service and delivery to a few more manufacturers of appliances. Wire or write for special Bulletin No. 5000 on Motors and Gearmotors.

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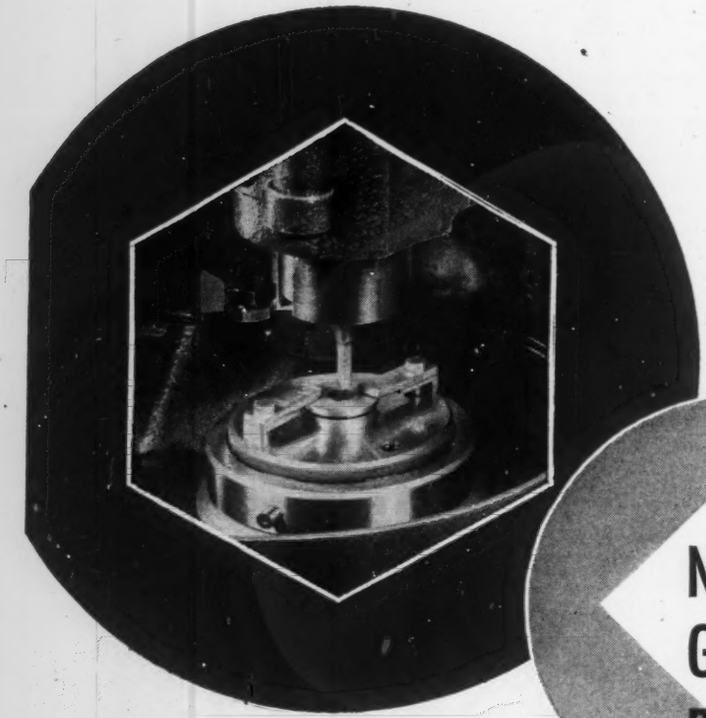
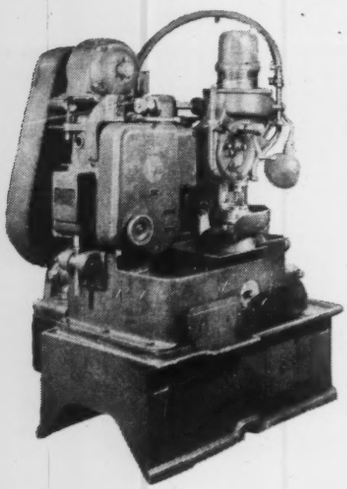


Nut and Bolt Trim Dies Generated to a PRECISE TAPER

Generating hexagonal trim dies on the Fellows Gear Shaper at The Cleveland Cap and Screw Company.



The high-precision ability of the Gear Shaper to generate symmetrical, angular or irregular contours, internal as well as external, carries suggestions to designers in many industries. Hexagon or square trim dies, for instance, can be generated to a controlled taper, as low as ½ degree, with close-tolerance duplicating accuracy.

The versatility of the Gear Shaper on non-gear jobs opens the door to the practical production of many intricate shapes... increases the scope of low cost machining at the designers' command. A reading of our illustrated book, "The Art of Generating with a Reciprocating Tool" will prove of interest to every production-minded design engineer. The Fellows Gear Shaper Company, Head Office and Export Dept., Springfield, Vermont. Branch Offices: 616 Fisher Bldg., Detroit 2... or 640 West Town Office Bldg., Chicago 12.

1947 MACHINE TOOL SHOW CHICAGO SEPT 17-26

Fellows

THE FELLOWS METHOD... MACHINES AND TOOLS FOR ALL OPERATIONS FROM BLANK TO FINISHED GEAR

do you have

Oil Seal Troubles?

Superfinish

can solve them!

For example, here's the case where a shaft with two oil seal bearings was installed with ground surfaces. Driven by a ¾ h.p. motor at 1,750 r.p.m., the oil seals created enough heat to burn the shaft and stop the motor. To make matters worse, it was later found that twice the original speed was necessary.

These oil seal surfaces were *Superfinished* and a new motor installed which turned the shaft at 3,500 r.p.m. With the *Superfinished* surfaces, no heat was developed at this increased speed. No further trouble was encountered.

Superfinishing is a quick, simple and inexpensive process. Oil seal bearings are but one of the many applications where it can save money, not only by eliminating trouble, but in many cases, by reducing your manufacturing costs as well. Gisholt engineers are ready to advise you concerning its applications.

GISHOLT MACHINE COMPANY

1215 East Washington Ave. • Madison 3, Wis.

1947 MACHINE TOOL SHOW CHICAGO SEPT 17-26

Look Ahead...

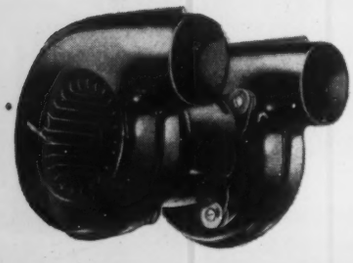
Keep Ahead...

with Gisholt...

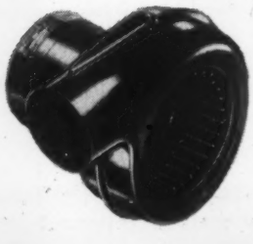
GISHOLT

TURRET LATHES • AUTOMATIC LATHES • SUPERFINISHERS • BALANCERS • SPECIAL MACHINES

Value Leaders—



LONG-LIFE Blowers



Sturdily built, carefully balanced Redmond Blowers are built in double units for delivery of 100 cubic feet per minute (free air), and in single units that turn out 50 cubic feet. Both are powered with resiliently mounted long-life Redmond Type "L" Micromotors.

in low range power

TYPE "L"

Redmond MICROMOTORS

LOOKING for value? Well, you'll find plenty of it in these Type "L" low range Micromotors—from their economical first cost, straight through their long useful years.

Here value is measured in keen engineering. It's perpetuated in skillful manufacturing . . . and proven in millions of famous products.

You're reading about the Value Leaders of the entire electric motor industry. These Redmond Micromotors represent a sound investment, for now and for good. They're uniformly precision built and individually checked. They run quietly and smoothly, and have earned an enviable reputation for dependability.

Learn the complete story of these Value Leaders. Get in touch with Redmond now. Ask about the Type "L" Micromotors, built in sizes from 1/150th up to 1/40th horsepower.

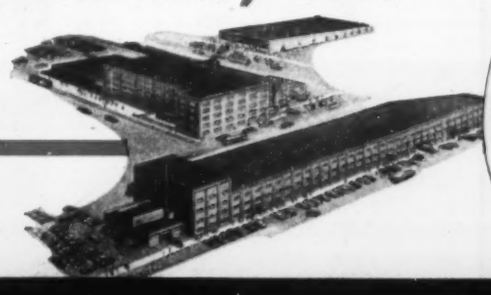
Redmond production capacity has been increased . . . prompt deliveries can now be offered.

Manufacturers of AC and DC Micromotors in sizes up to 1/20th horsepower.

Redmond COMPANY, INC.

Main Offices

OWOSSO, MICHIGAN, U. S. A.



Redmond facilities include 2500 employees and more than 5 acres of floor area.

REDMOND

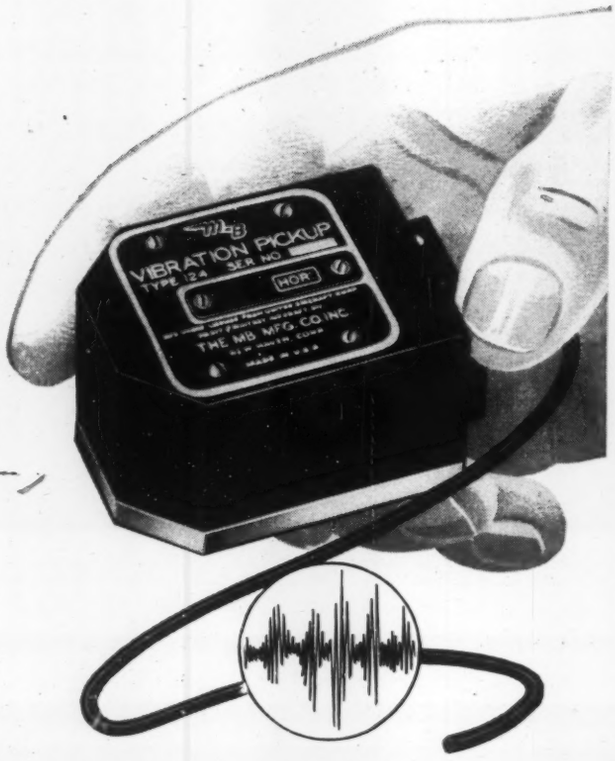
How this "VIBRATION DETECTIVE" can help you put out a better product

AN MB VIBRATION PICKUP detects vibration for you—or turns it into a useful yardstick for quality-control.

In inspecting a line of air-conditioning equipment, for example, you tell at a glance whether vibration is *within acceptable limits*. Or in operational tests of machines or engines, you can check them for smoothness—or determine their *variations*. In short, MB Pickups help you *locate* trouble *before* your product gets into the field to cause extra expense and loss of good will.

And it's an idea for process-control, too. Take the case of a ball-mill grinder, for instance. The MB Pickup could show you when material was properly milled by *changes in the pattern* of produced vibrations.

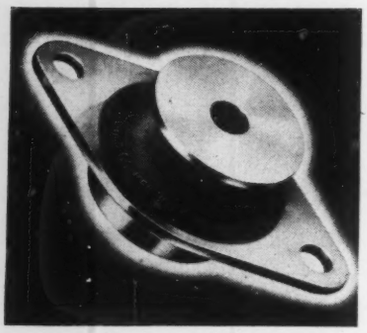
If you would like to know whether this sensitive pickup can be used in your own plant, why not let us hear from you? As foremost specialists in vibration, MB may have the answer—to your problem. There's no obligation.



PARTIAL TECHNICAL DATA

- Coil which moves between permanent magnets, transforms velocity changes into voltage changes.
- Convertible for horizontal or vertical operation.
- Electrically damped.
- Dimensions: 2-13/32 x 1-19/32 x 1-19/64". Weighs 8-1/2 oz.
- Range: velocity response flat from 10 to 1000 cps. Usable to 5 cps.
- Sensitivity: about 21 mv. per .001 inch double amplitude per 100 cps. No practical lower limit on amplitude.

HOW TO REALLY ISOLATE VIBRATION AT THE SOURCE



MB's flexible, Type 5 Isomode* mount has remarkable isolation-efficiency. For it was engineered with an equal spring rate in all directions—to absorb vibrations in *all six* possible modes of motion! (That's why you can also mount it at *any angle!*) It has softness *plus* stability; large load capacity *plus* compact size.

You can make vibration end at an Isomode-supported design—and with surprising simplicity! Get acquainted with the Isomode design chart which locates your best support points for you. Write for reprint of technical paper.

** Trade Mark Reg. U.S. Pat. Off.*

SEND FOR FREE BULLETINS

No. 124A gives further details on Pickup. No. 4-5 provides helpful design information on mountings. Reprint of Technical Paper describes Isomode Simplified Design Method. No. 405 describes economical mounting of industrial machinery. Write Dep't. A3.

THE MB MANUFACTURING COMPANY, INC.
1060 State Street
New Haven 11, Conn.
VIBRATION ISOLATOR UNITS • VIBRATION TEST EQUIPMENT

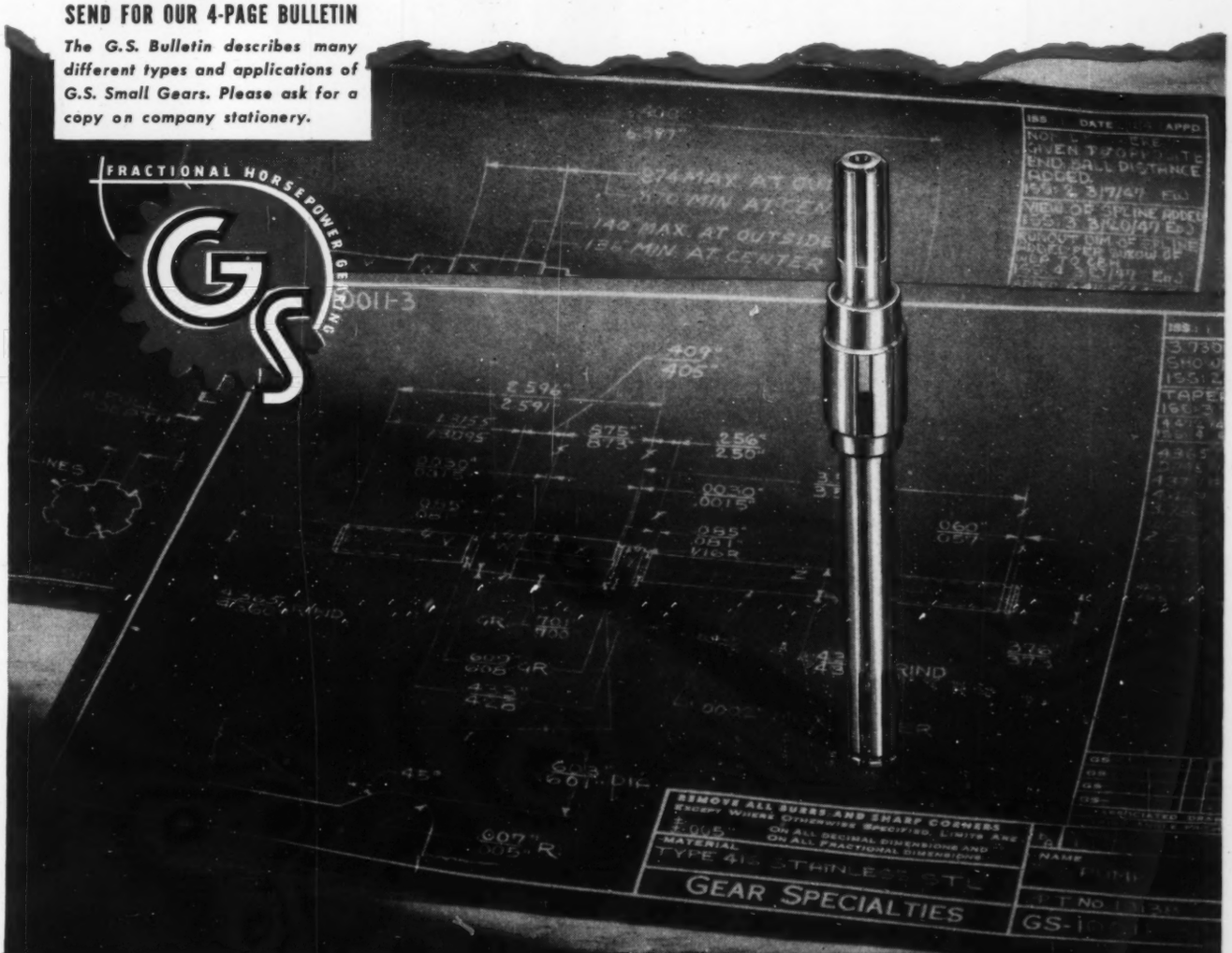
VIBRATION DIVISION

GET THE FRIENDLY COOPERATION OF EXPERTS

If a small gear problem is involved, "put it up to G.S.!" Get the valuable aid that only a highly trained staff of Fractional Horsepower Gear *Specialists* can give. They'll gladly suggest any necessary changes in design that will tend to improve its operation or make it more economical to produce in quantity. The G.S. organization of Small Gear Craftsmen offer you a combination of specialized skills, long experience and mechanical facilities unequalled in the history of the industry. We regularly serve many of America's biggest and most particular Small Gear users. Will you tell us, please, just how we can best serve YOU?

SEND FOR OUR 4-PAGE BULLETIN

The G.S. Bulletin describes many different types and applications of G.S. Small Gears. Please ask for a copy on company stationery.



GEAR Specialties

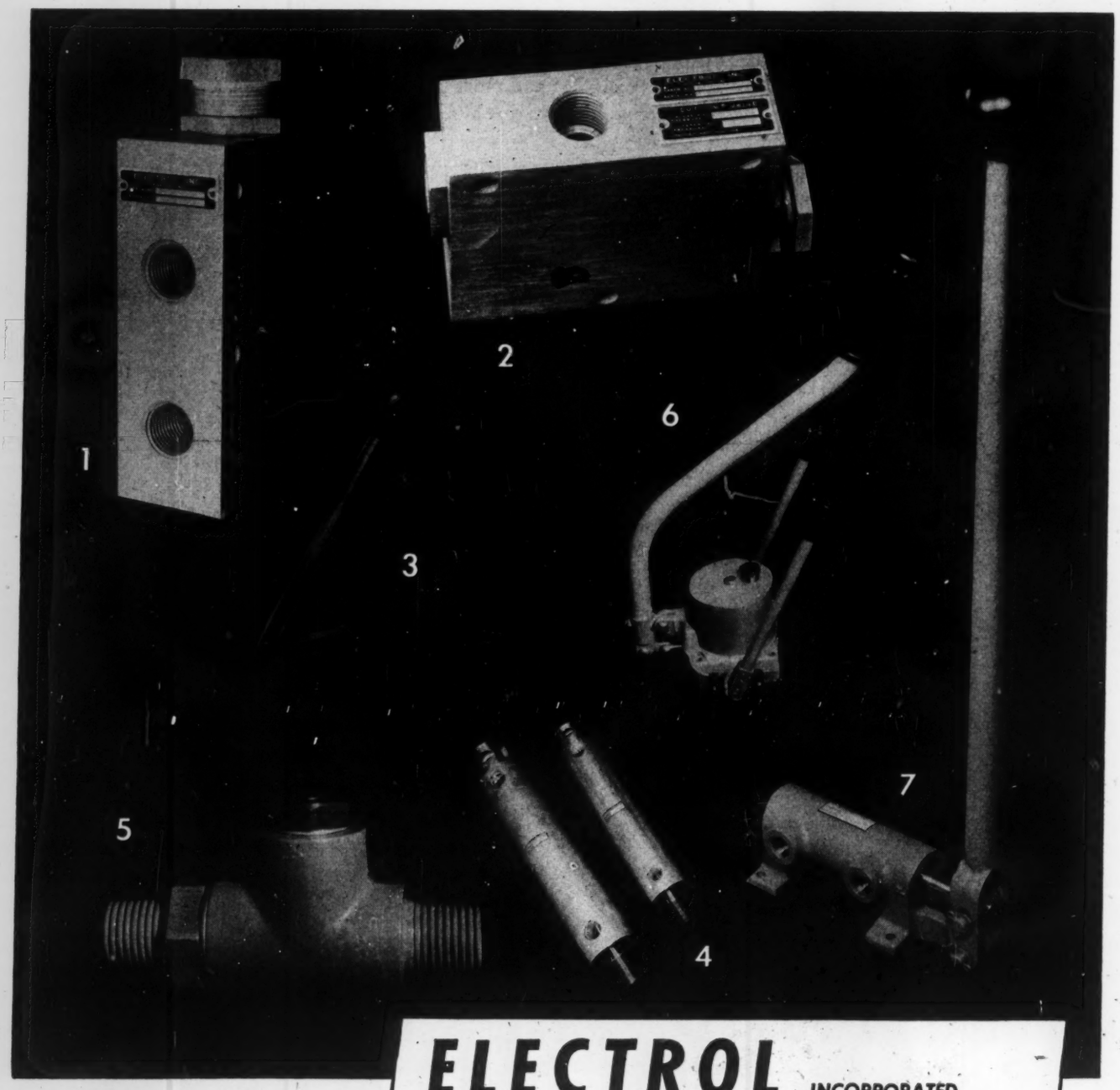
Spurs • Spirals • Helicals • Bevels • Internals • Worm Gearing • Racks • Thread Grinding

2635 WEST MEDILL AVENUE • CHICAGO 47, ILLINOIS

MEMBER OF AGMA

WORLD'S LARGEST EXCLUSIVE MANUFACTURERS OF FRACTIONAL HORSEPOWER GEARS

Industry uses these and many other
ELECTROL HYDRAULIC PRODUCTS



1 COMMERCIAL RELIEF VALVE
2 CUT-OUT VALVE
3 SLIDE SELECTOR VALVE
4 ACTUATING HYDRAULIC CYLINDERS
5 SPEED CONTROL VALVE
6 POWERPAK
7 INDUSTRIAL HAND PUMP

ELECTROL INCORPORATED

FOR BETTER HYDRAULIC DEVICES

KINGSTON, NEW YORK

Cylinders • Selector Valves • Follow-up Valves • Check Valves
Relief Valves • Hand Pumps • Powerpaks • Landing Gear Oleos
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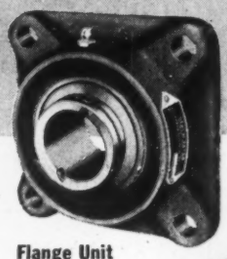
Valves • Cut-out Valves • Speed Control Valves

SEALMASTER

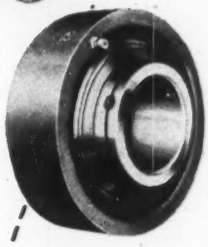
BALL BEARING UNITS

. . . important aids to the transmission of power

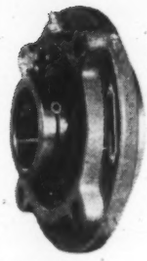
- QUIET IN OPERATION
- SELF-ALIGNING
- PERMANENTLY SEALED
- PRE-LUBRICATED
- NO HOUSING WEAR



Flange Unit



Cartridge Unit



Flange Cartridge Unit

Catalog No. 845 gives sizes, dimensions and complete engineering data.

SealMasters aid in the quiet, economical transmission of power for all types of new or *re-designed* machinery and equipment. Built to take both radial and thrust loads—SealMaster's *exclusive* combination of features contribute to best performance and economy.

Patented centrifugal flinger seal effectively excludes dirt . . . and retains lubricant. Each SealMaster unit is pre-lubricated at the factory and shipped ready for use.

SealMasters are self-aligning . . . they allow for misalignment in any direction without distortion of seal. Patented locking pin prevents outer race rotation and housing wear.

BEARING DIVISION

STEPHEN S-A DAMSON

MFG. CO.

18 RIDGEWAY AVENUE, AURORA, ILLINOIS

LOS ANGELES, CALIF. ★ BELLEVILLE, ONT.

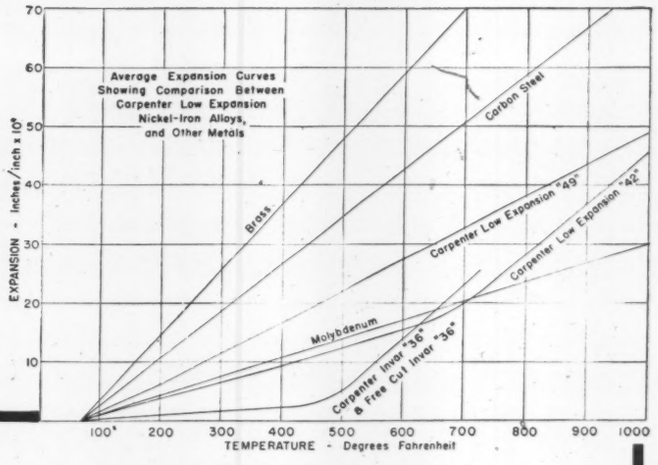
Factory Representatives and Dealers in All Principal Cities

WHEN YOU NEED

Constant Accuracy

IN SPITE OF

TEMPERATURE CHANGE



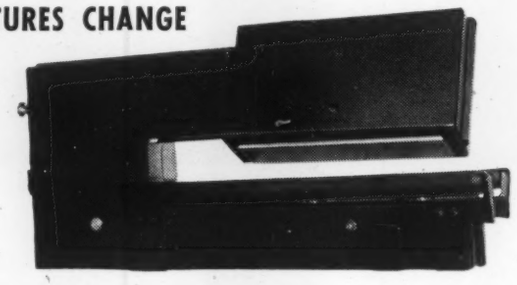
Where instruments or controls must operate through temperature changes, the relatively low expansion of Carpenter Invar "36" will help to insure constant accuracy.

Another important use for this low thermal expansion alloy is that of providing automatic motion, through the difference between its expansion rate and that of a high expansion alloy.

Carpenter Invar "36" has an expansion rate about 1/10 that of carbon steel at temperatures up to about 400°F—as indicated by this graph. For technical information on this low expansion alloy —or the free-machining grade, Carpenter Free-Cut Invar "36"—send us a note on your company letterhead and ask for the 21-page Carpenter High Nickel Alloy Bulletin.

INSTRUMENT REMAINS ACCURATE WHEN TEMPERATURES CHANGE

Rubberized fabric passes between two plates spaced exactly .150″ apart, while an electrical weighing device indicates the amount of rubber added. Several parts, including the two plates, are made from Carpenter Free-Cut Invar "36", to insure the instrument's accuracy in spite of temperature variations.

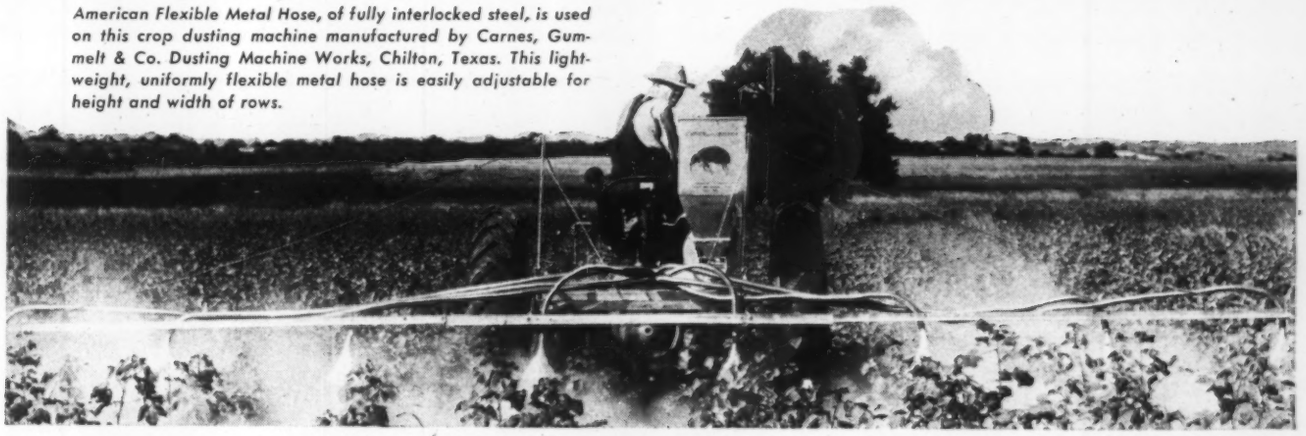


The Carpenter Steel Company, 120 W. Bern Street, Reading, Pa.

Carpenter High Nickel Alloys

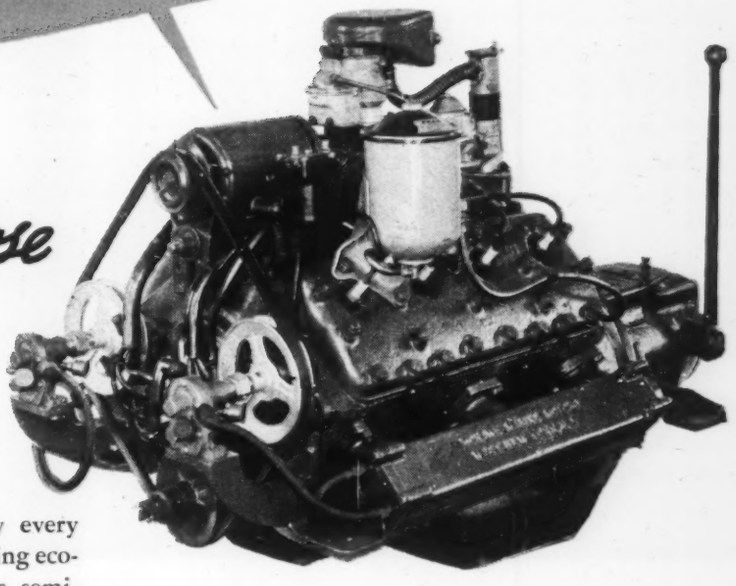
- Temperature Compensator "30"
- Carpenter Invar "36"
- Carpenter Free-Cut Invar "36"
- Glass Sealing "42"
- High Permeability "49"

American Flexible Metal Hose, of fully interlocked steel, is used on this crop dusting machine manufactured by Carnes, Gummelt & Co. Dusting Machine Works, Chilton, Texas. This lightweight, uniformly flexible metal hose is easily adjustable for height and width of rows.



From Dusting Crops to Cooling Marine Motors...

American Seamless Flexible Metal Tubing is used by Mohawk Marine Motors of Garfield, New Jersey, in this converted marine motor. This tubing, in cooling system connections, assures long life, 100% tightness under pressure, and valuable protection against heat, vibration and rough service.



Flexible Metal Hose performs best

There is no beginning and no end to the range of uses for American Metal Hose products. For many unusual applications, and in practically every industry, American Flexible Metal Hose and Tubing economically convey steam, oil, water, other liquids, semi-solids or gases—usually where vibration, misalignment or connecting moving parts create a problem.

American Seamless Flexible Metal Tubing, flexible as garden hose and leakproof as the seamless bronze tube from which it is made, is standard in sizes ⅛" to 4" I.D. Flexible Metal Hose, manufactured from strip in four spirally wound types, is available in brass, bronze, aluminum, steel and other metals, in sizes ⅛" to 12" I.D.

From these "American" products, you can obtain just the type of flexible connection that will best serve your needs. Tubing and hose can be fabricated with end fittings to your specifications.

For detailed information, please write for literature, and feel free to consult our Technical Department on any exceptional problems.

47292

ANACONDA
from mine to consumer

American

METAL HOSE

THE AMERICAN BRASS COMPANY

American Metal Hose Branch

General Offices: Waterbury 88, Connecticut

Subsidiary of Anaconda Copper Mining Company

In Canada: THE CANADIAN FAIRBANKS-MORSE CO., LTD., *Montreal 3, Canada*

SNAP-LOCK

TRADE MARK

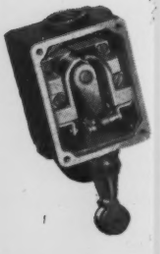
LIMIT SWITCH

...More Than Mere Snap Action

There's a real *difference*—ask any one of the several thousand satisfied customers who've bought Snap-Lock limit switches from us in the past ten years. Better still, ask one of our *new* customers (and we recently counted 75 in a 30-day period) why they specified Snap-Lock, whether for limit or our other types of switches.

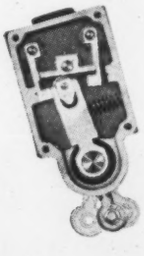
They may not go into detail on the design points—they may skip over the pure silver contacts with positive wiping action, the oil and dust resistant case, the locking action for both "on" and "off" positions, the completely separated mechanical and electrical sections—but they'll all tell you the Snap-Lock can *take it.*

A good limit switch is the mighty midget on your machine. It costs only a few dollars, but controls equipment worth thousands. Why take chances? Get the *only* switch that's built by machine tool builders, for the kind of punishment machine tool usage dishes out. When you want dependable, trouble-free performance under the most severe conditions, you'll want Snap-Lock. May we send you more information? Write for bulletin EM-42, showing different types of switches.



Electrical Features

Snap! and the circuit is closed—or opened. Pure silver contacts. Positive wiping action—with no arcing. Wiring connections easily accessible. Insulation in excess of specification requirements. Oil and dust resistant case. Single pole, double break, double throw.



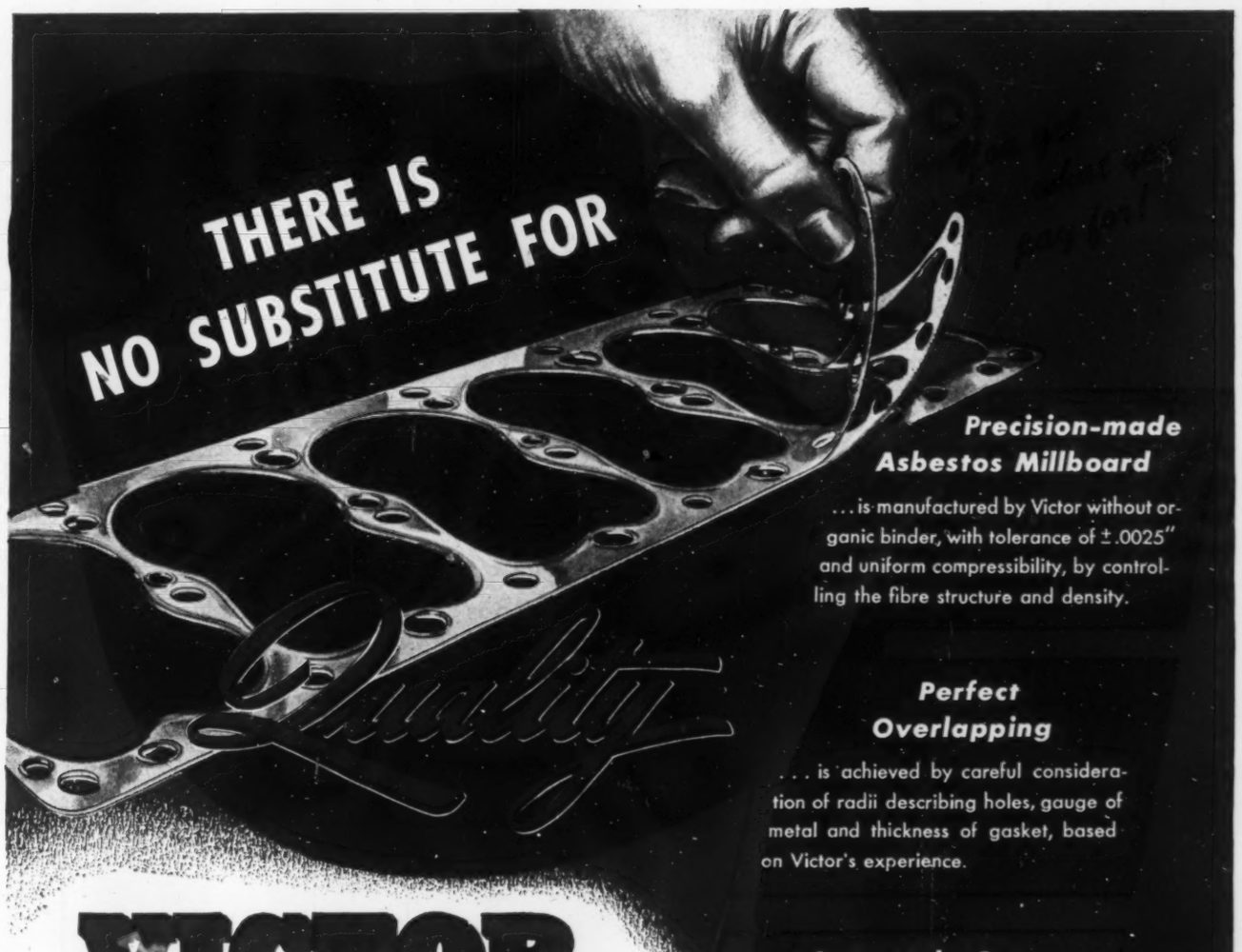
Mechanical Features

Locks in ON or OFF position. Rugged construction; completely separated from the electrical section. Operates on light pressure at 10° travel with additional 29° over-travel. Standard operating lever of drop-forged steel, equipped with hardened steel roller. Stainless steel shaft running in bronze bearing.

The NATIONAL ACME CO.

170 EAST 131st STREET • CLEVELAND 8, OHIO

SEE THIS EQUIPMENT DEMONSTRATED
Booth 628
Machine Tool Show
CHICAGO—SEPT. 17-26



Precision-made Asbestos Millboard

. . . is manufactured by Victor without organic binder, with tolerance of ±.0025" and uniform compressibility, by controlling the fibre structure and density.

Perfect Overlapping

. . . is achieved by careful consideration of radii describing holes, gauge of metal and thickness of gasket, based on Victor's experience.

VICTOR

The Greatest Name in the Gasket Industry

. . . has been built through years of painstaking research, craftsmanship and attention to manufacturing detail. As compression ratios of auto motors increased, with corresponding increases in pressure and temperature, Victor began to produce their own Asbestos Millboard. Experience has enabled them to develop accurate tables for computing perfect overlapping. And, since all gasket dies are produced by Victor craftsmen, accurate fitting is assured.

Victor's experience, research and production facilities are available to you. We welcome the chance to study your problem. VICTOR MANUFACTURING AND GASKET COMPANY, Box 1333, Chicago 90, Illinois.

Accurately Cut with Steel Dies

. . . made by Victor's skilled tool and die makers, Victor gaskets are uniform and fit perfectly as original or replacement part for the engine.

Exact Dimensions

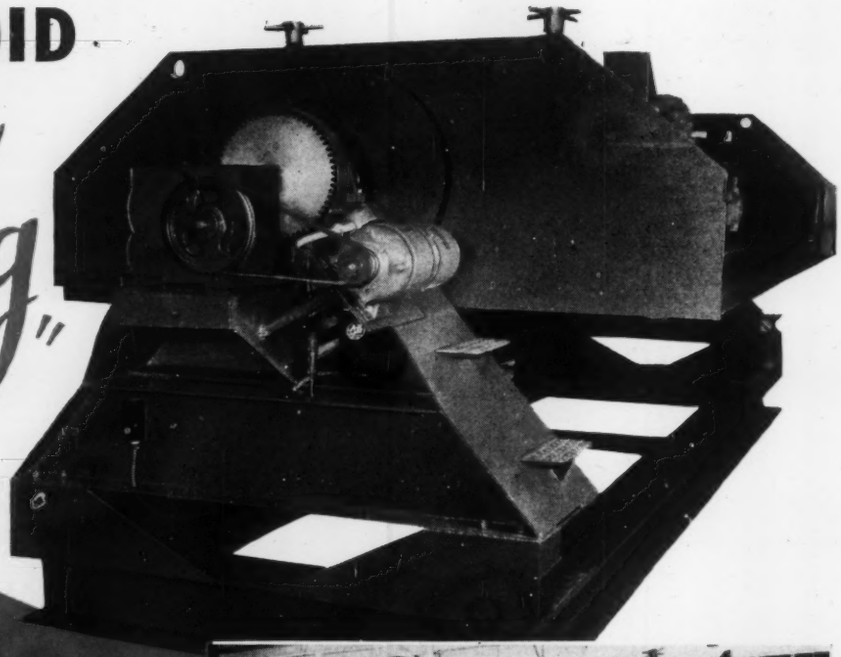
. . . which conform to all manufacturers' specifications are followed in producing gaskets that line with motor block openings and studs.

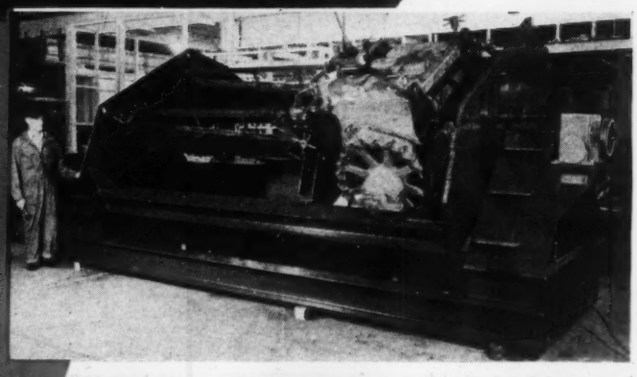
Manufacturer of **SEALING PRODUCTS** *Exclusively*

VICTOR GASKETS AND OIL SEALS

VICTOR

HOW TO AVOID "Over-motoring" HEAVY EQUIPMENT



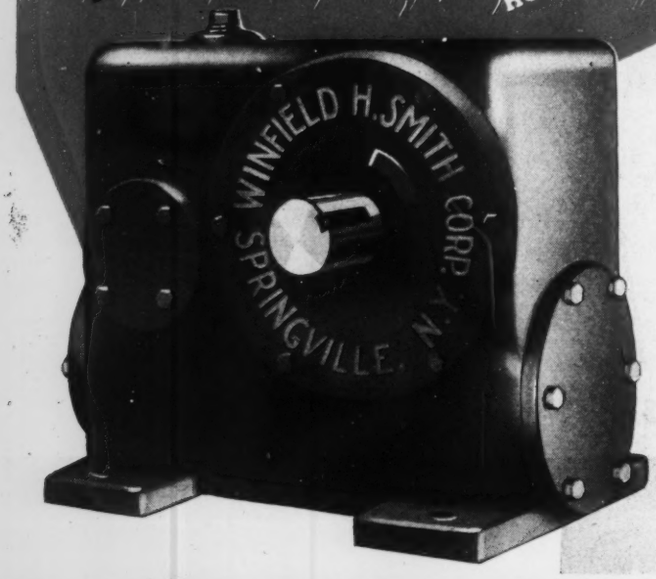


THIS WELDING FIXTURE Uses the RIGHT

Double Reduction WHS WORM GEAR

SPEED REDUCER

Based on TORQUE LOAD rather than INPUT HORSEPOWER



Welding Machines Mfg. Corp., 17325 Lamont, Detroit 12, Michigan, uses a WHS DB Series Reducer in the drive assembly of this Welding Fixture to produce the necessary low final speed of operation. WHS No. 6DB 159½-1 ratio Double Reduction Worm Gear Speed Reducer, having a 6800 inch pound torque capacity, was selected. This more than meets the torque load requirement and requires only 1 input H. P. at 1750 R. P. M.

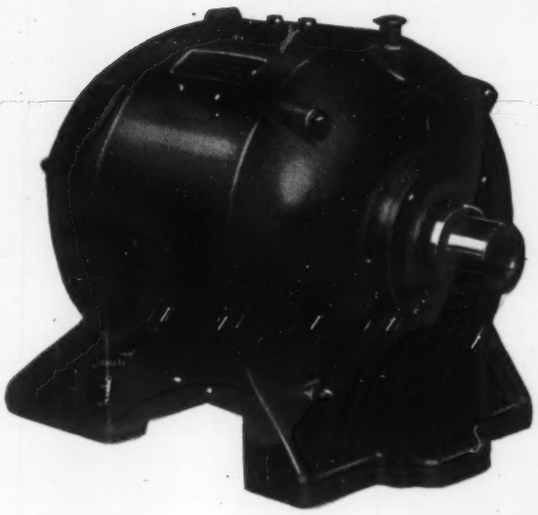
Just about any speed reduction problem can be solved by WHS . . . "The Most Complete Line of Speed Reducers Available from Any One Source". Write for our pocket Catalog No. 145.

MEMBER OF AGMA

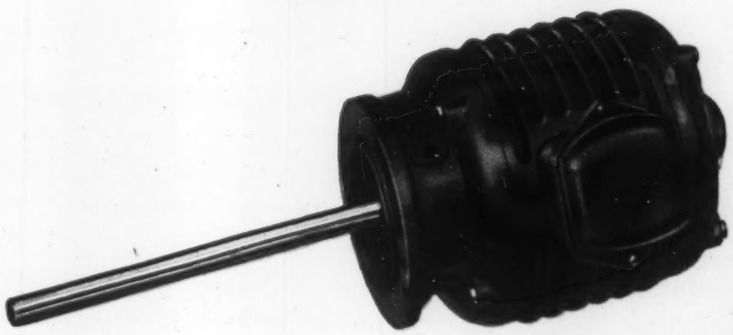
WINFIELD H. SMITH CORPORATION

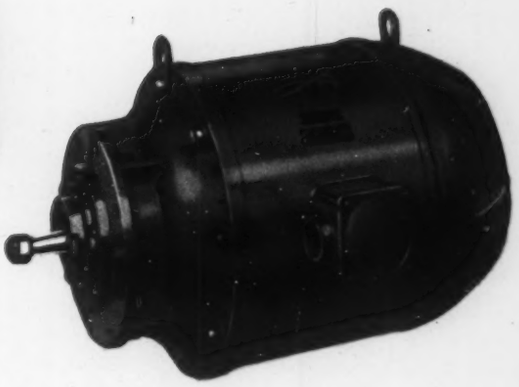
16 ELTON STREET . . . SPRINGVILLE . . . ERIE COUNTY . . . NEW YORK

Wichita City Lib--



There is a size and type LOUIS ALLIS electric motor for every industrial requirement.





THE LOUIS ALLIS CO., MILWAUKEE 7, WIS.

R.P.M. and H.P. alone won't do!

If you are planning a new product that will require a special electric motor in its construction, our engineering development department will welcome the opportunity of working with you.

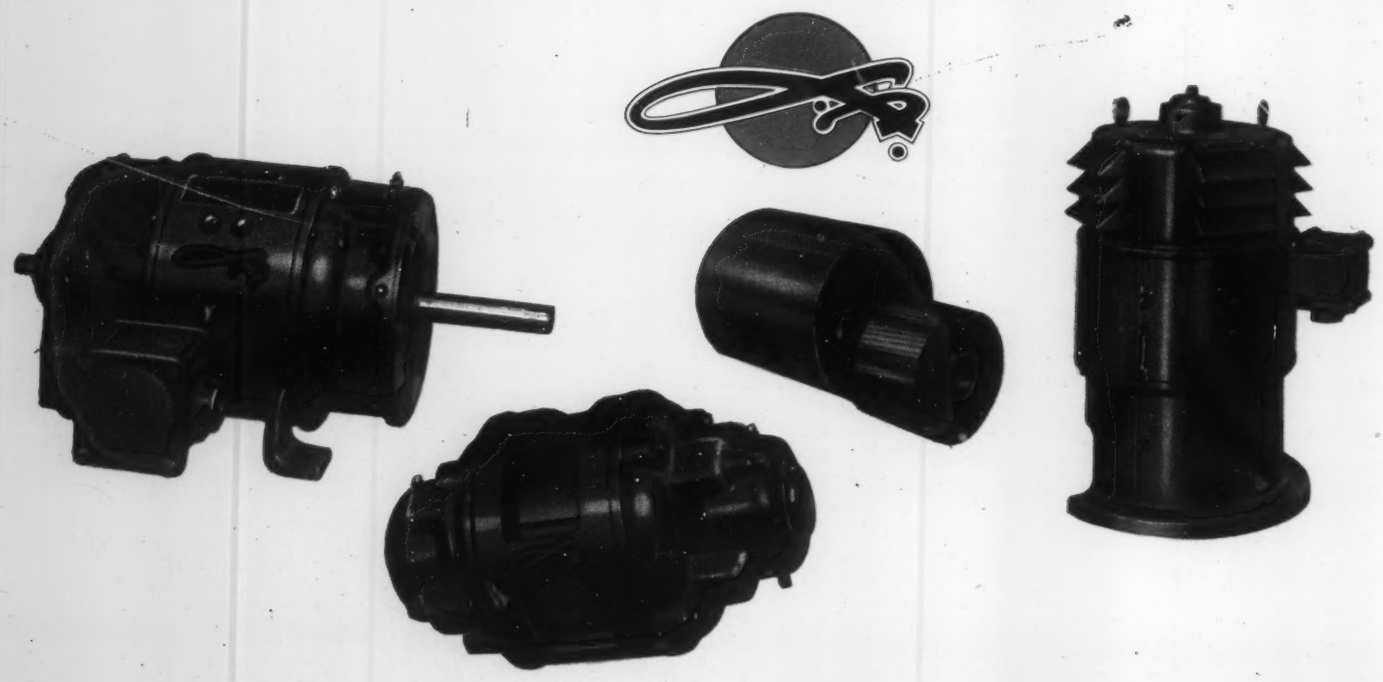
For over forty years we have been developing special motors for special jobs — and during the recent years many outstanding improvements in electric motor design, construction and performance have been created by us.

* * *

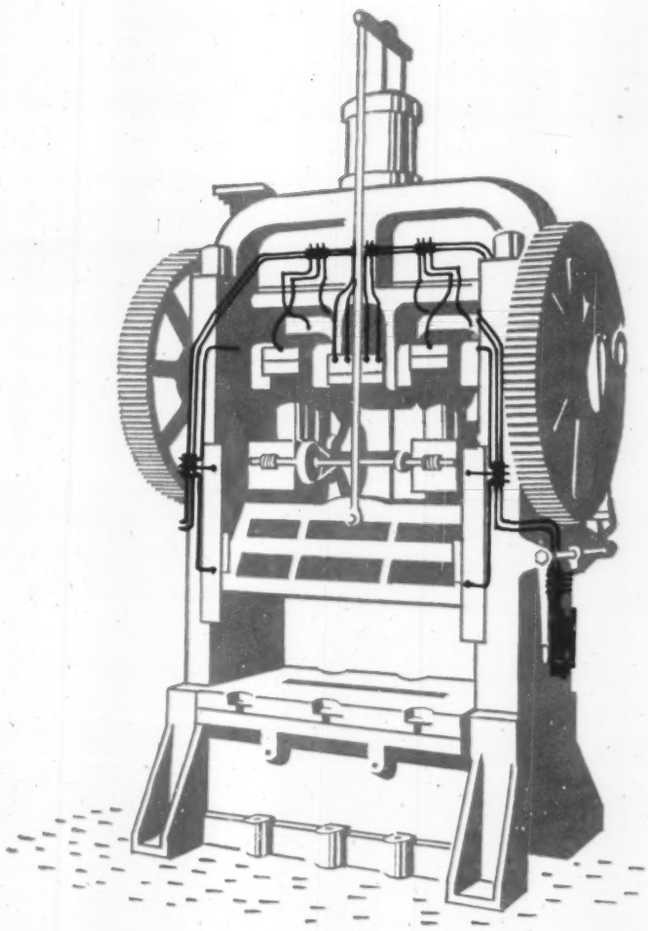
Machinery designers no longer attempt to use a standard motor for a special job — it is much more economical and efficient to obtain a motor with exactly the electrical and mechanical characteristics required to perform a specific job than it is to try to doctor up a standard "shelf" motor to do the job.

No matter what your electric motor requirements are — we will welcome the opportunity of serving you — your needs will receive our most prompt and careful attention in every way.

THE LOUIS ALLIS CO., MILWAUKEE 7, WIS.



Money saved on repairs soon pays for Farval



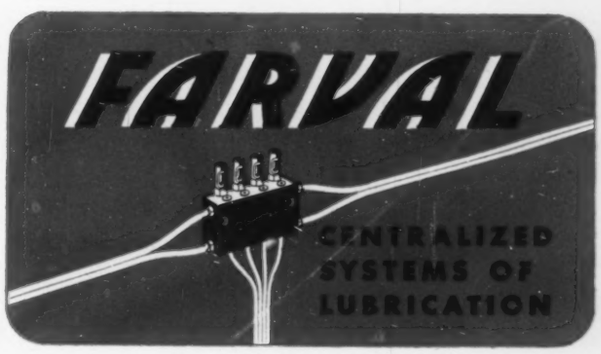
FARVAL—*Studies in Centralized Lubrication No. 93*

IN a metal working plant, lack of proper lubrication always kept a double crank press in trouble. Maintenance alone cost $161.00 in a six-months' period. Many hours of valuable production time, and valuable production, too, were lost while the press was down for repeated repairs.

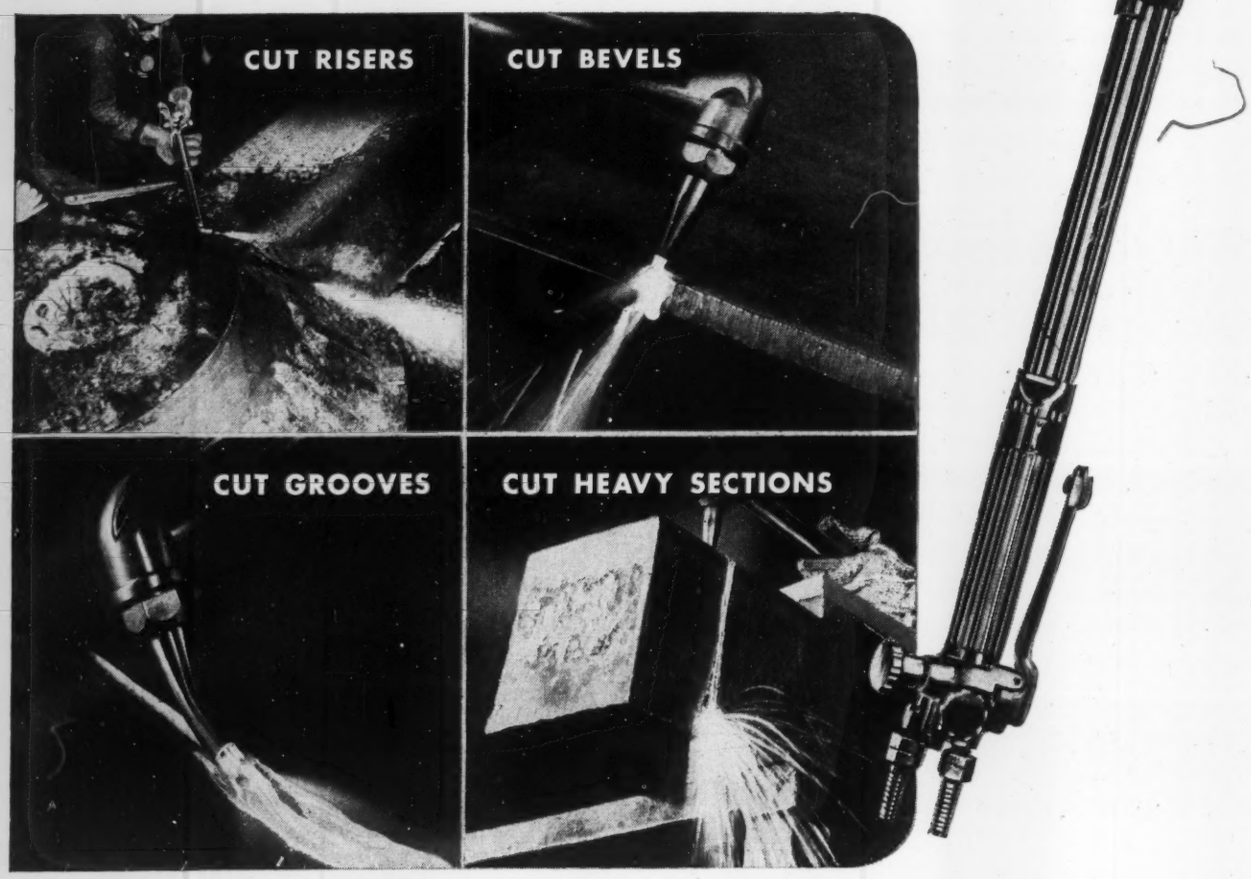
Then a Farval Centralized Lubricating System was installed. Proper lubrication brought an immediate, noticeable improvement. At the end of a full year's operation, not one cent had been spent on maintenance and not one minute of production time had been lost due to faulty lubrication. Farval had soon paid for itself.

Farval delivers oil or grease under pressure to a group of bearings from one central station, in exact quantities, as often as desired. Farval is the Dualine System with the Positive Piston Displacement Valve. This valve has but two moving parts and is fully adjustable, with a Tell-tale indicator at each bearing to show the job is done. For a full description of Farval, write for Bulletin 25. The Farval Corporation, 3265 East 80th St., Cleveland 4, O.

Affiliate of The Cleveland Worm & Gear Company, Industrial Worm Gearing. In Canada: Peacock Brothers Ltd.



Here's what you can do with this Blowpipe . . .



. . . and, by selecting from a choice of 57 different nozzles you can use the OXWELD C-32 to do almost any metal-cutting job practicable with manual equipment.

This sturdy cutting blowpipe is easy to handle and is built to give years of economical service even under the most strenuous conditions of use. A specially designed mixing chamber provides high flashback resistance. The C-32 operates on medium-pressure (5-15 lb. per sq. in.) acetylene.

Write for a catalog or ask Linde to demonstrate the advantages of this blowpipe.

The word "Oxweld" is a registered trade-mark of Union Carbide and Carbon Corporation.

THE LINDE AIR PRODUCTS COMPANY

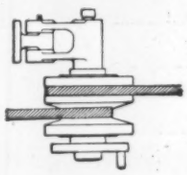
Unit of Union Carbide and Carbon Corporation

30 E. 42nd St., New York 17, N. Y. UCC Offices in Other Principal Cities

In Canada: Dominion Oxygen Company, Limited, Toronto

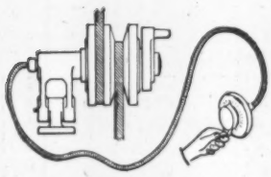
3-WAY DESIGN FOR *Improved Variable-Speed Control* ON YOUR LIGHT MACHINERY

Looking for a better method of giving the light equipment you design and build the advantages of variable-speed control? All right, consider this: American Speed-Jack Drives do *more* than deliver positive, stepless control of an infinite number of speeds through a 3-to-1 ratio! Yes, Speed-Jack Drives give you 3 big design and production advantages *over and above* positive variable-speed control on drives up to 1 H. P.



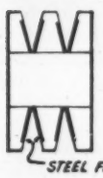
1. EASY, UNIVERSAL MOUNTING!

Speed-Jack Drives can be mounted horizontally, vertically or in *any* position in or on your machine. This design advantage is possible because flange movement is controlled mechanically—*not by uncertain belt pull.*



2. REMOTE CONTROL FEATURE!

Now speed changes on machines with hard-to-get-at drives can quickly be made through the use of a compact flexible shaft. This feature alone makes it easy to incorporate Speed-Jack Drives in the design of most any of your equipment powered by fractional-horsepower motors. Mounting of the control on a centralized control panel is facilitated.



3. NEW CONSTRUCTION ADVANTAGES!

The flanges on Speed-Jack Drives are of plastic faced with steel to combine light weight with extra wear resistance. Bearings are lubricated for life—need no attention because they're encased in a dust-proof hub.

Find out now how easy it is to give your equipment the *extra* design and production advantages of this different fractional-horsepower transmission. You'll find all the information you need in the new American Speed-Jack Drives Bulletin. It includes construction details, dimensions and an easy-to-use table that helps you select the proper sheaves for desired speed ranges. Write for your copy, today.

The American Pulley Company

4254 WISSAHICKON AVE., PHILADELPHIA 29, PA.

Technical Information on FELT...No. 1

FELT WICKS RELIABLE, CONTROLLED LUBRICATION

Four Basic Wick-Feed Lubrication Systems Meet Diverse Requirements Design Is Simple, Cost Is Low, Reliability and Long Life Assured

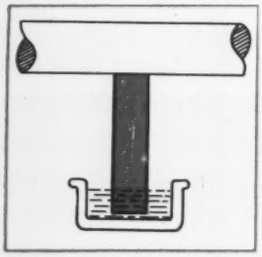
Lubrication by means of felt wicks permits oil to be fed to bearings and other moving parts, automatically and without failure or interruption. Wicks permit extremely fine control of lubricant, from many drops to a small fraction of a drop per minute. Where actual consumption of oil is low, oil-impregnated felt makes possible the use of completely enclosed parts, such as sealed bearings, and is in fact essential to them. In such applications it can be expected that lubrication will be supplied throughout the life of the part, and that no attention will be required between major overhauls.

The cost of a felt wick is low, in fact infinitesimal compared with the cost of the machine or part whose performance it protects.

TYPES OF WICK OILERS

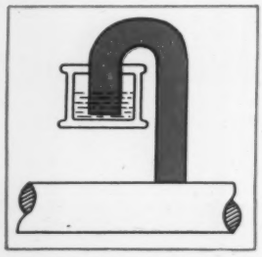
There are four types of wick lubrication systems. Choice of any given type depends upon such factors as the lubrication needs of the moving part, accessibility, available space, operating and servicing conditions, and similar matters of design and use. The Engineering and Research Laboratories of the American Felt Company will gladly collaborate with you in working out the design of the most desirable type of system and in selecting the proper size and grade of wick.

1. BOTTOM WICK OILER



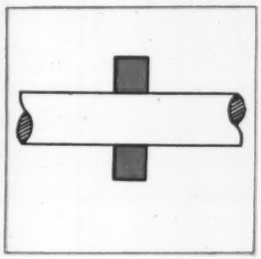
In this type, the felt wick is immersed in a reservoir of oil beneath the bearing, and through capillarity carries the oil upward to the point of lubrication. Maximum vertical wicking distance, about 6 inches. This is generally considered the most efficient system. Unused oil is returned to the reservoir, and no attention is required beyond occasional cleaning and replenishing of oil as required. An ideal system for apparatus such as motors, generators, and factory equipment.

2. SYPHON WICK OILER



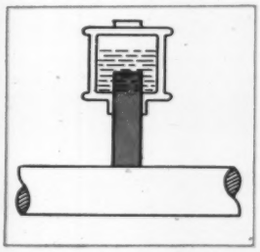
Felt wicks of this type are widely used, particularly where oil is to be delivered uniformly and at a controlled rate to a remote friction point. In addition to other methods of control, the flow of lubricant can be increased by increasing the vertical wicking distance from the reservoir to the point of lubrication, taking advantage of gravity.

3. ABSORBENT OR PAD FEED OILER



Here the lubricant is contained entirely within the felt, and is released automatically as required. This is the type often employed in sealed installations, though it may also be used in conjunction with a filler tube, the chief purpose of which is to act as a small reservoir. The oil absorption or storage capacity of felt is high. For example, SAE F-10 felt, recommended for pad oiling, will store oil of any viscosity to the extent of approximately 450 per cent of its own weight.

4. TOP FEED OILER



The reservoir is above the lubrication point, and oil is supplied through a felt wick inserted in an outlet in the bottom. In this case, the wick acts as an obstruction to control the flow of oil. Frequently the wick is mechanically constricted to effect further control while taking advantage of storage capacity between constriction and delivery point. This insures uniform lubrication and provides a surplus reserve of oil in the event of an empty reservoir.

SELECTION OF WICK FELTS

There are four types of felt recommended for wick lubricating systems. The physical characteristics of each are under complete control, and are standardized. As much care should be exercised in wick selection as in the choice of lubricants. The felt must have high absorption capacity and capillarity. Porosity must be controlled, filter action must be excellent, density, size, fibre quality and acid neutrality must be governed within close limits. Acid neutrality is necessary to avoid breaking down the oil or corroding metals. The wick must be highly cohesive, which requires medium to long fibres. Residual ash content must be low, to minimize glazing or scoring at the delivery point. All these requirements are thoroughly understood by American Felt Company engineers and production men. Manufacture, test and inspection methods have been developed over a long period of years, resulting in complete uniformity within the four grades, and reliable, predictable performance. The four grades are as follows:

No.	SAE Standard	Type of Wick or Lubricating System
7546	F-1	Round, Strip, Punched
7545	F-5	Strip, Washer, Absorbent Pad
51018	F-10	Absorbent Pad, Washer
51002	F-50	Ball Bearing Seal

Generator commutator and bearing lubricated with SAE 20 oil with a bottom wick oiler. A 3/16" diameter American Felt Co. Mdse 7546 wick with a wicking distance of approximately 1 inch is used for this critical lubricating job. With a shaft speed of 9000 RPM and a 200-hour oiling schedule these wicks always equal the life of the bearings, which are replaced after 100,000 miles or 2000 hours continuous operation.

HOW SUPPLIED

Wick felts are furnished either in bulk, or ready-cut into wicks to your own specifications, round, square, strip, pad, punched, or special types to meet your needs. By use of precision cutting machines of modern design, American Felt Company wicks are customarily supplied with a dimensional accuracy of plus or minus .005 inch.

OTHER USES

Felt wicks can of course be used to carry or control a wide range of fluids, such as water, ink, solvents. Felt can also be impregnated with viscous or solid lubricants such as grease, glycerine, dispersions of micronized graphite, tallow, hydrogenated and sulphonated oils, silicone greases, and with various waxes, thus providing protection at points where loads and speeds are such that oil is not required.

SEND FOR DATA SHEET

The material in this advertisement has been condensed from American Felt Company Data Sheet No. 6, "Wicks and Lubrication." This eight page Data Sheet is the basic authority upon the subject. It contains full technical data, including formulae, charts and graphs, tables. From it any engineer can calculate wick performance and arrive at a design and specification that will meet the requirements of a given application. Write on your letterhead and a copy will be sent you. Along with it you may wish to receive a list of the 15 American Felt Company Data Sheets containing technical information on the various characteristics, types and applications of felt and felt products.

BASIC PRINCIPLES OF WICK LUBRICATION

Wick-rise rate or capillarity varies directly with wick density, inversely with oil viscosity.

Wicking distance likewise varies directly with wick density, inversely with oil viscosity.

Oil feed or delivery rate is governed by the absorption capacity of the wick, its capillarity, the cross sectional area of the wick, and the wicking distance.

HENCE: With *syphon wicks*, the greater the wicking distance, and the greater the cross sectional area, the greater the flow.

With *bottom wicks*, the shorter the wicking distance, and the greater the cross sectional area, the greater the flow. (Maximum recommended distance about 6 inches.)

With *syphon, bottom, and pad wicks*, flow can be reduced by mechanically compressing or restricting a section of the wick between the reservoir and point of delivery.

All factors involved in the design of a wick lubrication system have been scientifically studied by the American Felt Company, and are susceptible to accurate mathematical calculation. Felt is an engineering material, and its performance can be determined in advance with as much accuracy as that of any metal or other substance.

ENGINEERING USES OF FELT

Wicks	Filtering Fluids and Gases
Oil and Grease Retainers	Packing
Dust Seals	Polishing
Gaskets	Caulking
Cushioning and Shock Absorbing	Insulation
	Sound Absorption
	Vibration Isolation

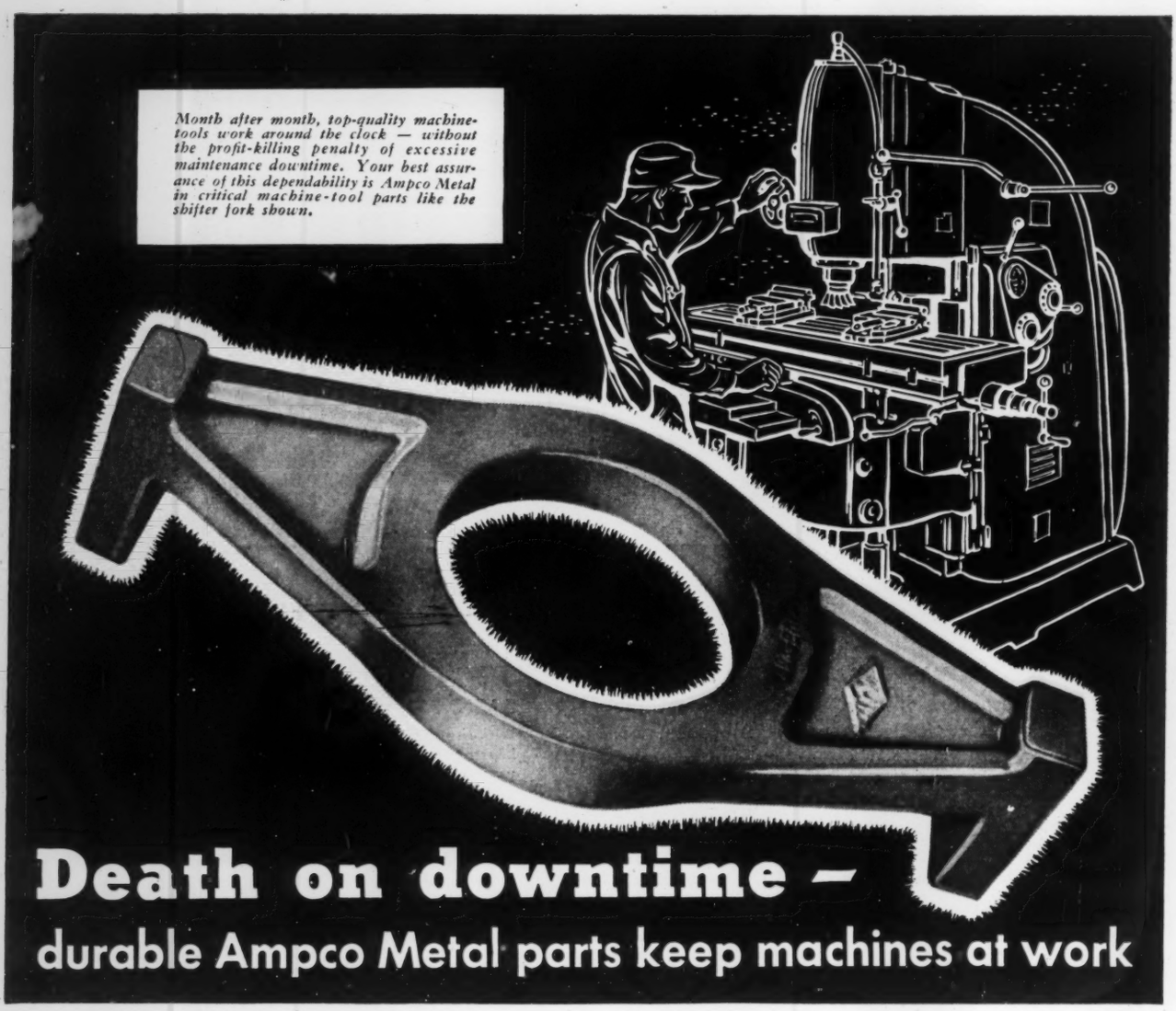
Felt is an engineering material of great versatility. It can be made hard as a board, or soft as a kitten's ear, oil-conducting or oil-sealing, fire-proof, water repellent, or fungi resistant, white as snow or any color including black, and it can be cut, punched, turned, ground, pressed and moulded to shape.

American Felt Company

TRADE MARK

Engineering and Research Laboratories: Glenville, Conn. PLANTS: Glenville, Conn.; Franklin, Mass.; Newburgh, N. Y.; Detroit, Mich.

SALES OFFICES: New York, Boston, Philadelphia, Atlanta, Rochester, Chicago, Detroit, Cleveland, St. Louis, Dallas, San Francisco, Los Angeles, Portland, Seattle, Montreal



Death on downtime –
durable Ampco Metal parts keep machines at work

This wear-resistant aluminum bronze reduces maintenance time and costs

There's no ceiling on the cost of expensive downtime, but there's good insurance against it—durable Ampco Metal in critical machine-tool parts. The extra wear-resistance of this modern aluminum bronze means longer and better service under extreme operating conditions.

Ampco Metal parts are a mark of quality to look for when you buy new equipment. Replace worn parts in your present machines with Ampco Metal to reduce replacement frequency in the future and slash your maintenance costs to a new low.

Ampco Metal is a superior aluminum bronze of closely controlled quality. Its exceptional resistance to wear makes it last several times longer than ordinary alloys of this type. Ampco Metal can be produced by centrifugal- and sand-casting, extrusion, or forging processes according to your requirements.

Let your nearby Ampco engineer help you select the proper grade for your needs, from the seven standard grades and several modifications available. For complete information, write for Bulletin 71.

Ampco Metal has 7 outstanding performance advantages—

Excellent bearing qualities • High strength-weight ratio • High compressive strength • High impact and fatigue values • Corrosion resistance • Efficiency at extreme temperatures.

REG. U. S. PAT. OFF.

AMPCO Metal

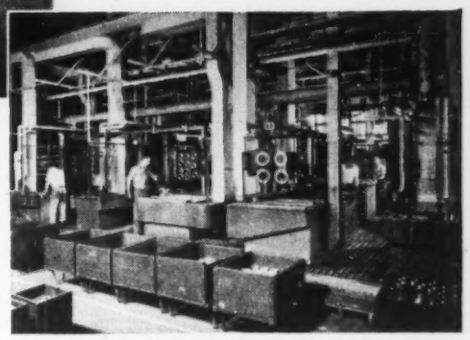
Ampco Metal, Inc.
Dept. MD-7 • Milwaukee 4, Wis.
Field Offices in Principal Cities

AD-32

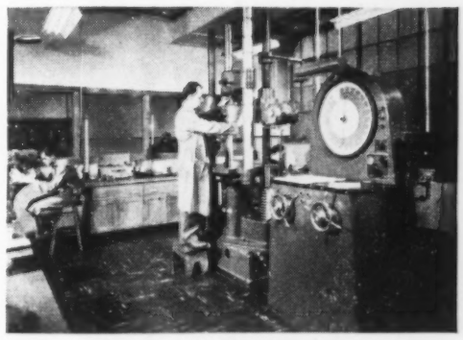
FACILITIES TO PRODUCE THE *Gears* YOU NEED

Controlled atmosphere furnaces, quenching presses in the foreground

Carburizing and nitriding furnaces



Section of plating department



Physical testing laboratory to provide control of heat treating

. . . take heat treating for example

If you use gears—spur—helical—worm or bevel—Foote Bros. can fill your needs. In two large plants, you will find the latest in modern machinery backed by nearly a century of manufacturing skill to produce gears for practically every requirement. Giant gears 20 feet in diameter for cement kiln or sugar mill drives. Extremely high precision gears for aircraft engines. Industrial gears for gas or diesel engines, tractor transmissions, mining and construction machinery, machine tools or any industrial application.

Typical of the completeness of the facilities of Foote Bros. is the heat-treating department.

In this department are facilities to bright copper plate—Rochelle salt copper plate—cadmium plate—tin plate and dichromate.

Here are carburizing and nitriding furnaces to gas carburize, liquid carburize, cyanide and nitride.

Controlled atmosphere furnaces permit exact control of hardening. They normalize to relieve forging stresses and anneal and temper to provide stress relief after hardening or grinding.

In addition to heat-treating equipment, this department has Gleason and Hannifin Quenching Presses for distortion control—facilities for sub-zero treatment—and facilities for shot peening to increase fatigue life.

The completeness of heat-treatment control is an indication of facilities in every department of Foote Bros. available to gear buyers. We welcome inquiries for any type of gear in any quantity to meet your needs.

FOOTE BROS. GEAR AND MACHINE CORPORATION
Dept. O, 4545 S. Western Boulevard • Chicago 9, Illinois

FOOTE BROS.

Better Power Transmission Through Better Gears

Three bulletins on Foote Bros. products are available. Check the coupon for the ones you are interested in.

☐ FOLDER "WHATEVER YOUR NEEDS IN GEARS"
☐ BULLETIN "AIRCRAFT QUALITY GEARS"
☐ BULLETIN "FOOTE BROS. POWER UNITS"

Name.....

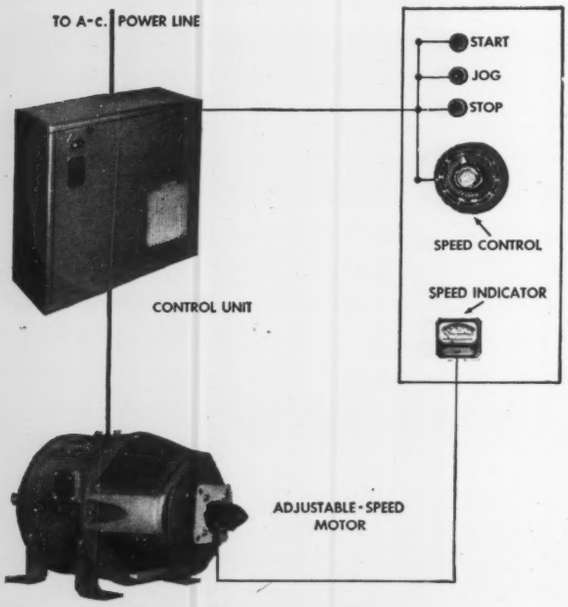
Address.....

City.....*State*.....

RELIANCE V★S DRIVE

Greater PRODUCTION with ADJUSTABLE-SPEEDS

...from A-c. Circuits



Conveniently-packaged, space-saving V★S Drives are available from 1 to 200 hp.

Actually, Reliance V★S Drive is an *electric transmission.* At the touch of a button your machine can be started or stopped. Turn the knob of a rheostat and it can be accelerated or decelerated smoothly—over an infinite range of stepless speed changes. And with this *All-electric, Adjustable-speed Drive operating from A-c. Circuits,* control can be either automatic or manual . . . at the machine or from remote stations. The net result of V★S control is greater efficiency, faster production, lower costs—as already proved in every industry. That's why it will pay you to write today for Bulletin 311.

RELIANCE ELECTRIC & ENGINEERING CO.
1079 Ivanhoe Road • Cleveland 10, Ohio

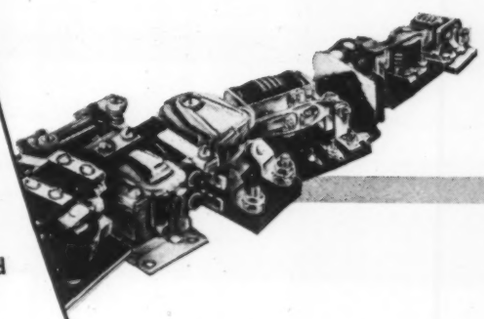
Appleton, Wis. • Birmingham • Boston • Buffalo • Chicago • Cincinnati • Dallas
Denver • Detroit • Gary • Grand Rapids • Greenville, S. C. • Houston • Kansas City
Knoxville • Los Angeles • Milwaukee • Minneapolis • New Orleans • New York
Philadelphia • Pittsburgh • Portland, Ore. • Roanoke, Va. • Rockford • St. Louis
San Francisco • Seattle • Syracuse • Tampa • Tulsa • Washington, D. C.
Sao Paulo, Brazil

RELIANCE A-C D-C MOTORS

"Motor-Drive is More Than Power"

Exactly
THE RIGHT RELAY FOR YOUR APPLICATION

MIDGETS
INDUSTRIAL TYPES
LARGE POWER TYPES (up to 60 amperes)
"MEMORY" TYPES (mechanical latch, electrical re-set)
SENSITIVE LOW-POWER
INSTRUMENT CONTROLLED
MERCURY CONTACT (swing types, clapper types)
SEQUENCE (ratchet and multipole types)
DIRECT CURRENT ("Nutcracker" types)
HIGH-VOLTAGE
LAMP CONTROL
GENERAL PURPOSE TYPES
POLARIZED
CLOSE DIFFERENTIAL
VIBRATION-RESISTANT
OVERLOAD
INDUSTRIAL MOTOR REVERSING
TELEPHONE AUXILIARY SIGNALLING COMBINATIONS
TIME DELAY (inertia, motor-operated and thermal types)



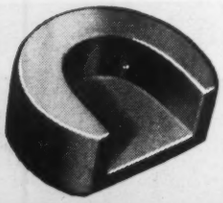
The tremendous number of Struthers-Dunn Relays and Timers makes it possible to meet most specifications EXACTLY—*and from standard types.* All are highly adaptable as to contact, coil and mounting arrangements.

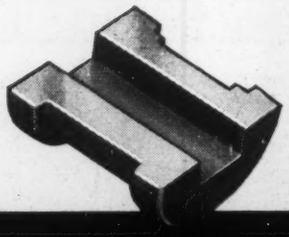
STRUTHERS-DUNN, INC. • 146-150 N. 13th ST., PHILADELPHIA 7, PA.

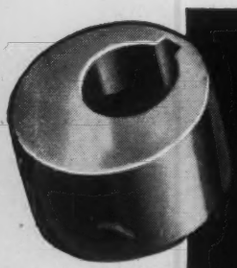
Write for Data Bulletin on any type

STRUTHERS-DUNN

ATLANTA • BALTIMORE • BOSTON • BUFFALO • CHICAGO • CINCINNATI • CLEVELAND • DALLAS
DENVER • DETROIT • HARTFORD • INDIANAPOLIS • LOS ANGELES • MINNEAPOLIS • MONTREAL
NEW YORK • PITTSBURGH • ST. LOUIS • SAN FRANCISCO • SEATTLE • SYRACUSE • TORONTO

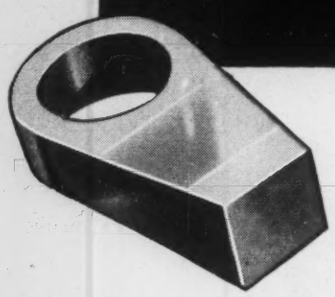






Our cards are on the table

—NOT UP OUR SLEEVE!



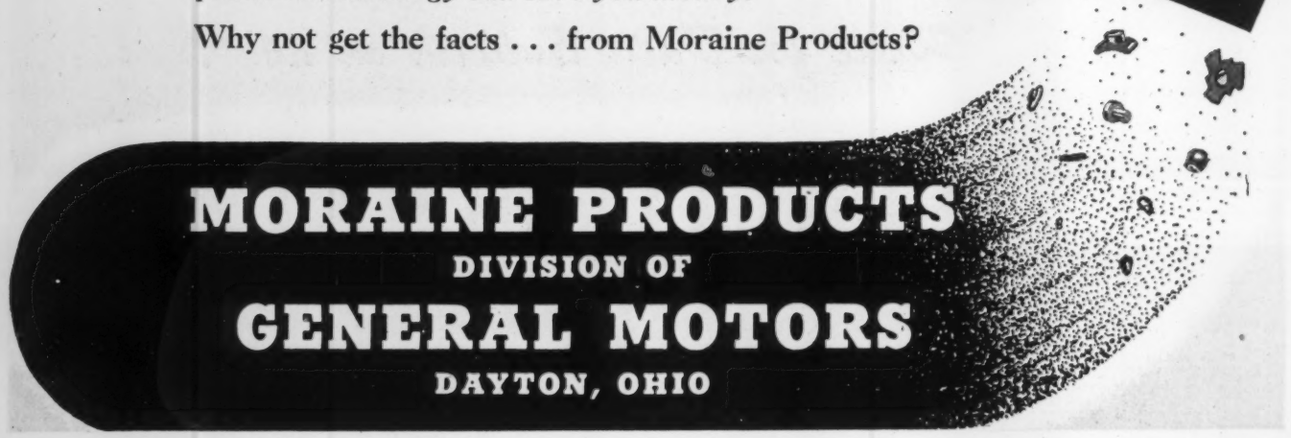
Some parts are practical for powder metallurgy. Others are not.

Here at Moraine Products it is an established policy to take only the kind of business that results in lasting satisfaction for the customer. If a part involves tolerances that cannot be uniformly maintained, or shapes and contours that lead to structural weaknesses after sintering—*you'll get a straight answer from Moraine Products.* We'd rather lose an order than run a bluff based on "theoretical" facts and figures.

Our cards are on the table in respect to costs, too. We tell you frankly that powder metallurgy cannot compete with conventional methods on small-run, "job lot" orders, where the tooling cost is out of proportion. *On the other hand, if you have need for a large quantity of identical parts, finely finished and held to close commercial tolerances, there is good reason to believe that powder metallurgy can save you money.*

Why not get the facts . . . from Moraine Products?

METAL POWDER PARTS BY MORAINE



MORAINE PRODUCTS

DIVISION OF

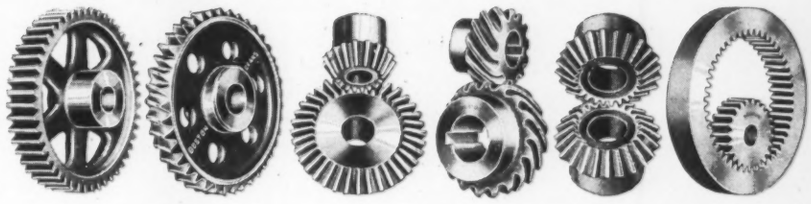
GENERAL MOTORS

DAYTON, OHIO

How shall I rig up that drive?

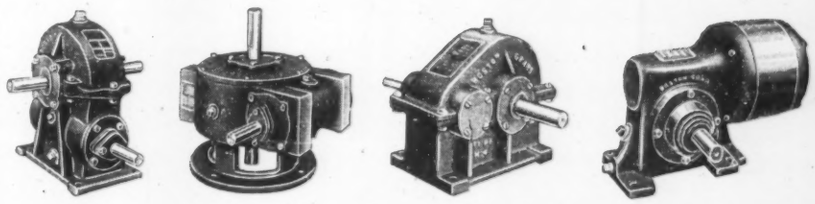
USING GEARS

Your drive may require any one of these types of gears — spur gears, worms and worm gears, bevels, helicals, miters, internal gears — or a combination of these types. For easier selection of your requirements the Boston Catalog lists many stock sizes from ¼" diameter up to 40" diameter.



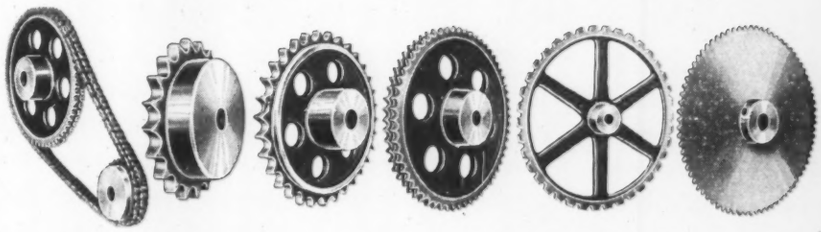
SPEED REDUCERS

Made-to-order gear housings and lubricating problems are eliminated when you select a modern speed reducer — a completely engineered and inclosed gear box ready for installation. The Boston Catalog lists 20 different speed reducer types and also gives you valuable data to use in the selection of the right unit for your drive.



SPROCKETS & CHAIN

For more flexibility in a positive drive, sprockets and chain may be your answer. Long center distances are a primary feature. Stock sprockets are listed in the Boston Catalog if your drive is from "flea" power up to 40 horsepower. For your information complete specifications and selection data are given in the Boston Catalog.



Where and how do I buy these products?

SIMPLY ORDER BY CATALOG NUMBER FROM YOUR NEAREST DISTRIBUTOR. SEND FOR CATALOG 54 AND COMPLETE LIST OF 65 STOCKING DISTRIBUTORS. BOSTON GEAR WORKS, INC., NORTH QUINCY 71, MASS.

BOSTON GEAR WORKS, INC., NORTH QUINCY 71, MASS.

Please send me ..... copies of your General Catalog 54 and complete list of stocking distributors.

NAME_____

COMPANY_____

STREET_____

CITY_____ ZONE_____ STATE_____

Good habit for Piping Specifiers see the Complete CRANE Line first

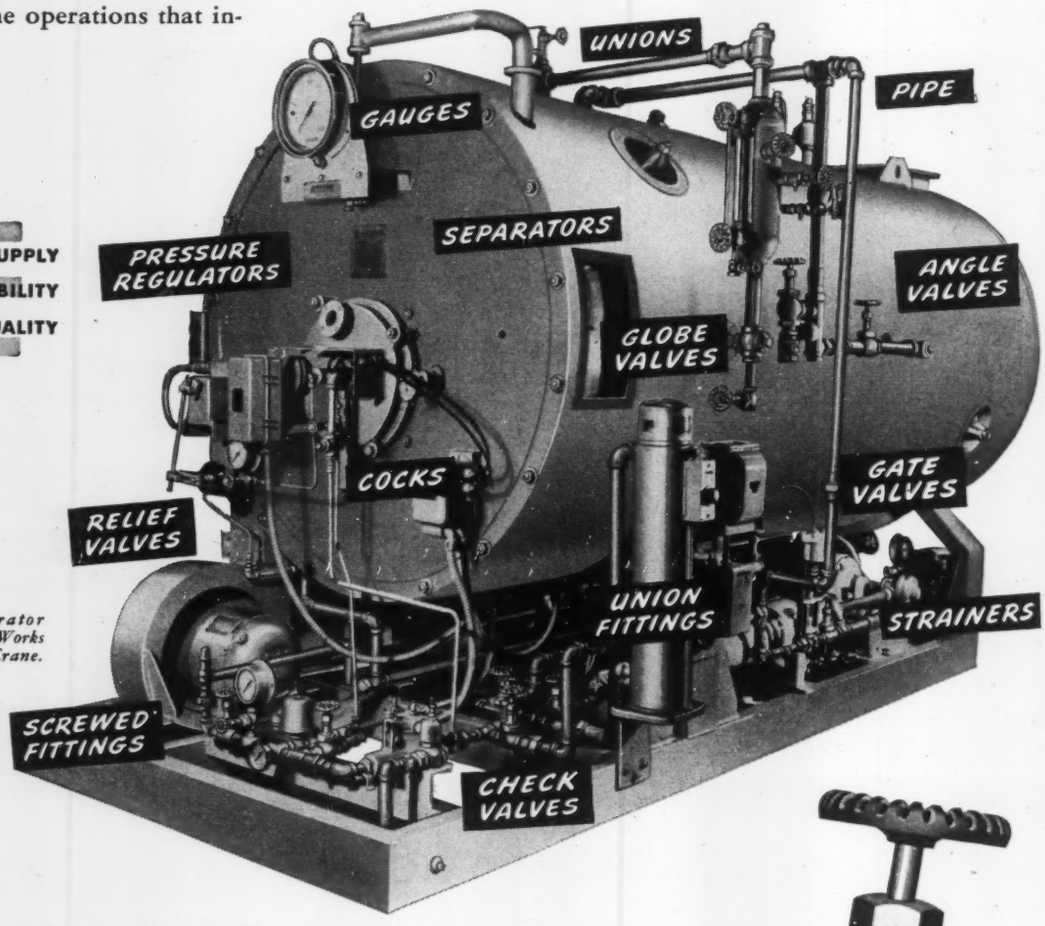
Chances are you won't look any further than Crane for piping . . . because there's no need to. Whatever your design calls for in brass, iron, steel, and alloy piping materials, you can specify from Crane's unequalled selection.

Also, your buyers and storekeepers will find their work much simplified when they rely on Crane as the single source of all piping equipment. Later, when your product is assembled in the plant, the operations that involve piping will go smoothly—thanks to Crane Co.'s undivided responsibility.

When your customer gets the finished machine, he'll be completely satisfied with the flow control equipment. For he knows that Crane means Quality—quality unexcelled for 90 years.

CRANE CO., 836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving all Industrial Areas

ONE
SOURCE OF SUPPLY
RESPONSIBILITY
STANDARD OF QUALITY



Amesteam Generator made by Ames Iron Works . . . equipped by Crane.

BEST FOR TOUGH SERVICE—*For throttling and for frequent operation, Crane recommends plug type disc globe and angle valves. Extra wide seating surfaces of hard-wearing metals provide maximum resistance to wire-drawing and damage by foreign matter. Disc taper permits accurate flow regulation. Made in brass in 150, 200, and 300-lb. steam pressure classes. Also in cast and forged steel for similar and higher pressures. See your Crane Catalog.*

EVERYTHING FROM . . .

VALVES • FITTINGS
PIPE • PLUMBING
AND HEATING

CRANE

FOR EVERY PIPING SYSTEM

If you use springs . . .

remember—better springs make better products.

THE technical "know-how" acquired in more than a century of manufacturing wire products . . . plus greater precision in inspection and manufacture are the reasons for the outstanding performance of U·S·S American Quality Springs.

These superior springs resist fatigue and hold their shape with unusual success. They give additional life to your product.

When you specify American you get better springs for your product. And because our production facilities are second to none, you can usually count on speedy delivery of springs in *whatever* quantity you need.

Let our spring engineers help you select the right springs for your product. No matter what type you need, we can supply them . . . for we produce every type and size of compression, extension, torsion and flat springs in common use.

THE JOHN DEERE AUTOMATIC BALER

The vitally important tooth bar spring on the pick-up as well as several other springs on the press are American Quality Springs.

AMERICAN STEEL & WIRE COMPANY

Cleveland, Chicago and New York

Columbia Steel Company, San Francisco,
Pacific Coast Distributors

Tennessee Coal, Iron & Railroad Company, Birmingham,
Southern Distributors

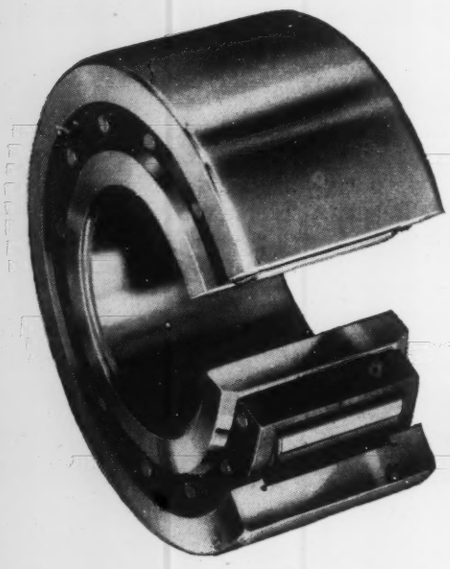
United States Steel Export Company, New York

UNITED STATES STEEL

AMERICAN STEEL & WIRE COMPANY
USS
AMERICAN SPRINGS
UNITED STATES STEEL

U·S·S American Quality Springs

REDUCE SHUT-DOWNS *with* ROLLWAY Right-Angle Loading



Cut Maintenance Costs
Get Longer Bearing Life

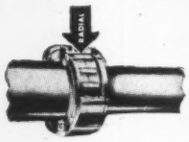
Right-Angle Loading splits compound loads into the two component parts of pure radial and pure thrust . . . and carries each of these components on separate bearing assemblies.

ROLLWAY
RIGHT-ANGLE-LOADED
BEARINGS

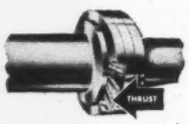
WHAT THEY DO

Prevent wedging of rollers and pinch-out ● Reduce roller end-rub, with its wearing friction ● Hold starting and operating torque at a minimum ● Eliminate complicated stresses ● Since only pure radial or pure thrust loads can be imposed on any single bearing assembly, unit pressures are substantially reduced ● Since all loads are carried at right angles to the roller surface, compound or oblique loads are avoided, and so are the resultants of the oblique loads ● Right-angle loading permits Rollway Bearings to carry greater radial or thrust load capacity in any given dimension ● Right-angle loading assures solid cylindrical rollers of greater roller mass and uniform roller cross-section . . . greater resistance to shock loads and vibration . . . longer life expectancy under continuous heavy-duty service.

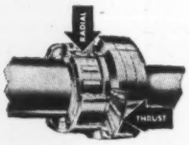
HOW THEY WORK



When it's pure radial load, the load bears at a right angle to the rollers.



When the load is pure thrust, it bears at a right angle to the rollers.



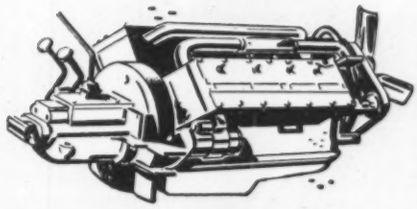
When radial and thrust are combined, the two loads are resolved separately at a right angle to the rollers.

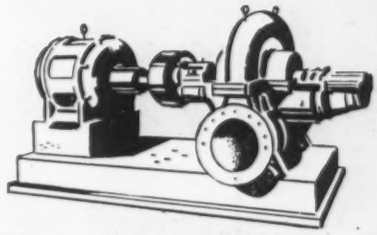
FREE SERVICE / **Get the RIGHT Bearings for Your Particular Needs. Rollway Engineers will gladly make necessary calculations, drawings and supply other required information for a complete understanding of your bearing needs. Strictly confidential. No charge, of course.**

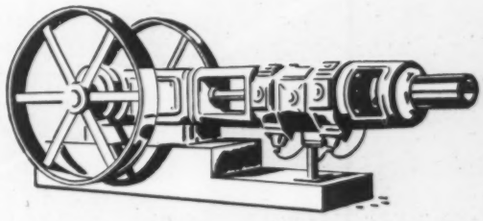
ROLLWAY BEARINGS

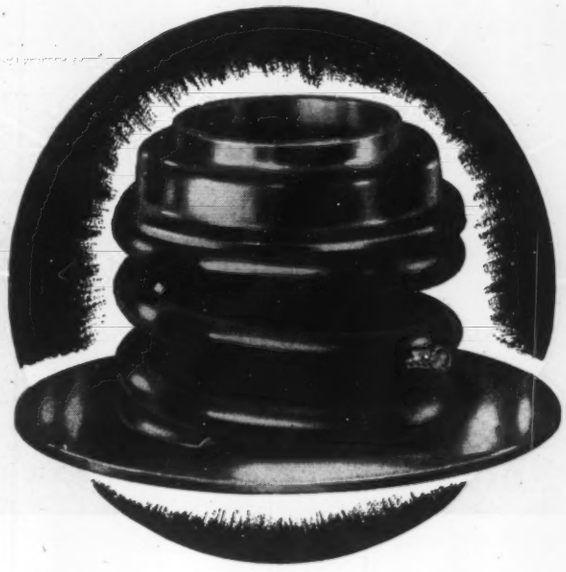
ROLLWAY BEARING COMPANY, INC., SYRACUSE, N. Y.

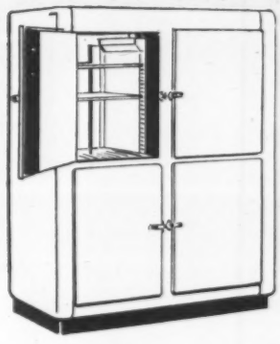
SALES OFFICES: Philadelphia • Boston • Pittsburgh • Cleveland • Detroit • Chicago • Minneapolis • Houston • Los Angeles











Stops shaft leaks before they start

NEED TO SEAL a rotating shaft—*securely*—against seepage of gas or liquid? Then your best bet is a Sylphon Seal. It does the job quickly, easily, at low cost.

Covering a wide size range—for tiny instruments up to large industrial and marine installations—Sylphon Shaft Seals are engineered on order for specific applications. They hold firmly, are easily mounted, withstand heavy pressures up to hundreds of pounds, seal shafts gas- or liquid-tight.

Sylphon Seals are used successfully on compressors, washing machines, pumps, hydraulic transmissions and in a wide variety of other applications. Write today—find out how they can help solve *your* problems. Ask for Catalog NK-825. . . contains complete details and idea-starters.

FIRST WITH BELLOWS

THE FULTON SYLPHON CO. KNOXVILLE 4, TENN.

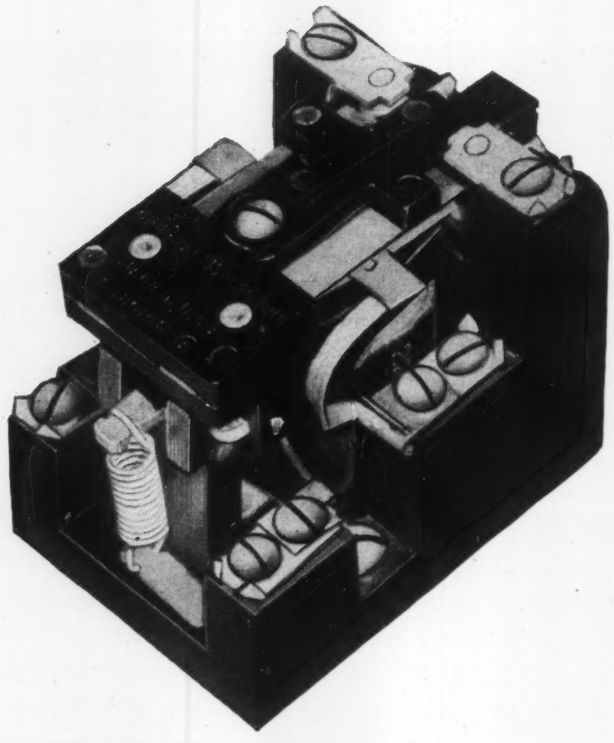
FULTON SYLPHON

Temperature Controls Bellows Bellows Assemblies

Canadian Representatives, Darling Brothers, Montreal

Designer's

Resourceful Relay



Three contact arrangements: single-pole, single-throw; double-pole, single-throw; double-pole, double-throw.

Here's a trim, compact magnetic relay you can use either as a fractional-horsepower motor starter or as a relaying unit in a thousand and one control circuits. Handles up to 10 amps at 230 volts a-c. Comes in four forms: open, enclosed, back-of-panel connected, and plug-in—with a choice of three contact arrangements on each form.

You'll find that this sturdy, compact, general-purpose relay fits as though it were made-to-order in many applications. Measuring less than 3 x 2 x 2⅜ inches, these General Electric CR-2790E magnetic relays may be mounted on an insulated or noninsulated base. The terminals are easily accessible. Contacts are of heavy silver.

Enclosed form

In the enclosed form, convenient knockout conduit entrances are provided top and bottom. The U-shaped cover makes for easier wiring and inspection. Check Bulletin GEA-4668.

NEW—For designers of back-connected panels, General Electric offers a new modification of this relay with 2¾-inch studs which project from the back of the relay through the panel.

NEW—Relay is also available in plug-in form for quick replacement—particularly applicable for process control circuits where operating continuity is vital. Relays can be interchanged quickly and easily.

Digest

TIMELY HIGHLIGHTS ON PRODUCTS

SPEEDS TRACING

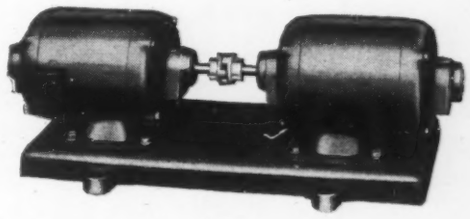
The bright, permanent identification colors of Flamenol control cable are a big help in circuit tracing. They eliminate the need to ring out every circuit; they mean important savings in installation and maintenance time. So does the ease with which Flamenol strips. And remember, you can't beat Flamenol for resistance to oils, acids, alkalies, sunlight and other old enemies of cable. No extra protective covering is needed; you save space and get a neater wiring job. Flamenol control cable is available in Nos. 12 and 9 AWG stranded wire sizes with 2 to 12 conductors per cable. Bulletin GEA–4352 gives you the story of this and many other types of Flamenol wire and cable.

A TIP ON TERMINALS

General Electric terminal boards are designed to save lost motion and assure connections that *stay tight*. Boards are molded from strong, durable Textolite, and are available in 4-, 6-, 8- and 12-pole sizes, equipped with marking strips. Each terminal will take one No. 8 stranded conductor, two No. 12 stranded conductors or three No. 12 solid conductors (all AWG). Covers optional. Check Bulletin GEA-1497A.

WELCOME BACK!

The popular T-27 general-purpose time switch is back on the market—welcome news to designers of heating, lighting and other equipment calling for automatic timing on a daily repeating schedule. Can be provided with astronomic dial for closing and opening circuits at dusk and dawn, and with an omitting device to skip the ON operation for selected days of the week. Minimum time interval is 3 minutes. 115 or 230 volts; 25, 50, or 60 cycles; SP-ST, SP-DT, DP-ST, or DP-DT. See Bulletin GEA-3339.



SHORT DELIVERY

On These D-c Fractionals

It's been a long time since we've talked about short deliveries, but engineering and manufacturing facilities are now available to give you just that on the following d-c fhp motors, generators and motor-generator sets:

D-c fractional-horsepower motors for pumps, feed and traverse drives, and many other machine-tool applications.

Generators and motor-generator sets for magnetic chucks, exciters, and similar applications where a limited supply of either a-c or d-c power would not otherwise be available.

The above applications are just a few of the many which these readily available fhp units will fulfill. For a complete description of these motors, generators and m-g sets check Bulletin GEA–4871 on coupon.

GENERAL ELECTRIC COMPANY
Apparatus Dept., Section, B668-55, Schenectady 5, N. Y.

Please send me the following bulletins:

- GEA-4668—Magnetic relays
- GEA-4352—Flamenol wire and cable
- GEA-1497A—Terminal boards
- GEA-3339—General-purpose time switch
- GEA-4871—D-c fractional horsepower motors

See your copy of Sweet's 1945 File for product designers—it contains 102 pages listing G-E equipment.

NAME .....

COMPANY .....

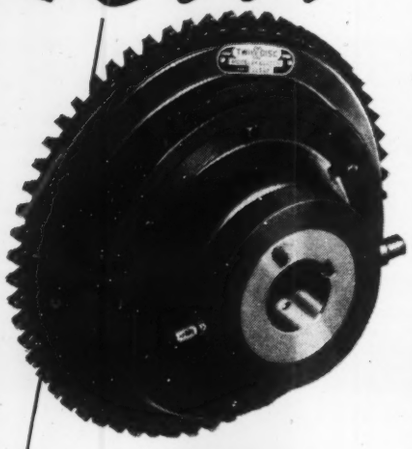
STREET .....

CITY ..... STATE .....

Proved adaptable...

The adaptability of *standard* Twin Disc Friction and Hydraulic units to a wide variety of applications is one reason why today the list of engine builders and equipment manufacturers who standardize on Twin Disc Products reads like the industry's blue book. These manufacturers have found that there is a *proved* Twin Disc Friction Clutch or Hydraulic Drive for every clutch or power take-off problem.

The Model EH heavy-duty friction clutch and the hydraulic power take-off, both illustrated here, are only two units in the full line of Twin Disc Clutch Company Products which have fully demonstrated their superior operation in many types of machinery and equipment . . . in a wide variety of applications. Each is offered in a wide range of sizes . . . each is *designed, built* and *applied* with the skill which has been characteristic of Twin Disc workmanship for 28 years. TWIN DISC CLUTCH COMPANY, Racine, Wisconsin (Hydraulic Division, Rockford, Illinois).

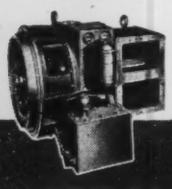


The adaptability of standard Twin Disc Clutches and Hydraulic Drives to a wide variety of applications is graphically told in Bulletin No. PR-9. Write for your free copy today.

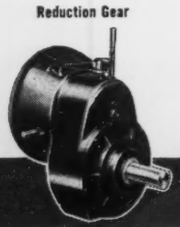
The Model EH Friction Clutch has been proved on many types of industrial equipment and machinery. It is furnished in single or two-plate assemblies, from 14" to 42", in capacities ranging from 65 to 875 hp. It comes equipped with gear tooth drive, and either driving rings or driving spiders.

Twin Disc Hydraulic Power Take-off capacities range up to 300 hp, are suitable for application to all types of internal combustion engines. Furnished in sizes of 14.5", 17.5" and 21".

Hydraulic Torque Converter



Reduction Gear



Machine Tool Clutch

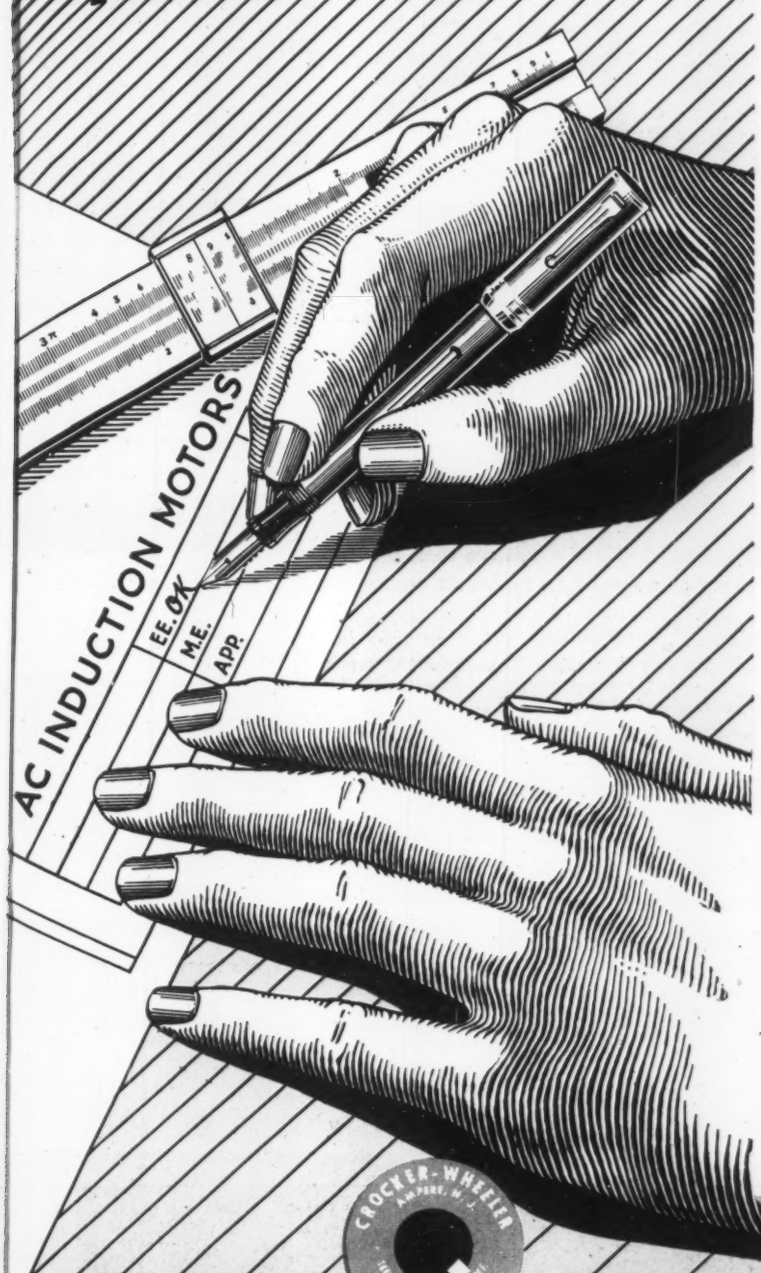
TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES
REG. U.S. PAT. OFF.

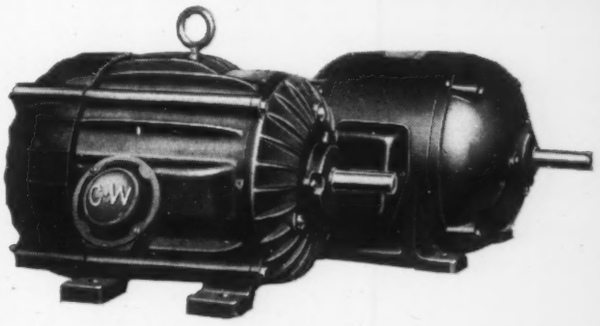
Tractor Clutch

Marine Gear

SPECIALISTS IN INDUSTRIAL CLUTCHES SINCE 1918

THE HANDS THAT DESIGNED THESE AC MOTORS HAD 21,900 DAYS OF EXPERIENCE





Crocker-Wheeler know-how, acquired through 60 years of manufacturing quality electric motors and generators, has broadened its horizons. A new ownership and management assumed control of this pioneer company during the war. This new management has developed Crocker-Wheeler's production and research facilities to match the recognized superior quality of its products.

Infused with modern methods, progressive management and millions of dollars for retooling, Crocker-Wheeler is now building in large quantity two great new lines of induction motors, combining the traditional Crocker-Wheeler quality and experience with manufacturing methods and tools as modern as tomorrow.

The New PROTECTED-TYPE BA and the New SEALEDPOWER-TYPE C (totally-enclosed, fan cooled) induction motors are only two of the improved machines Crocker-Wheeler has perfected with skill and knowledge gained from 60 years of background and experience . . . Built to do *your* job even better than before. CW-19

KEEP YOUR EYE ON CROCKER-WHEELER

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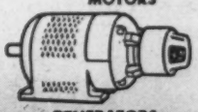
SQUIRREL CAGE MOTORS

WOUND ROTOR MOTORS

DIRECT CURRENT MOTORS


GENERATORS

FLEXIBLE COUPLINGS

HANNIFIN

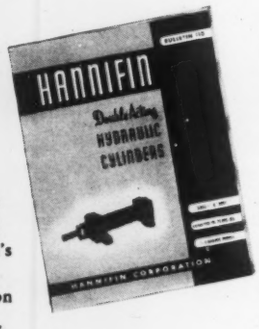
Everything you want in

HONED *Tru-Bored*

Model CN — *one of 11 different mounting styles!*

...HYDRAULIC CYLINDERS

This sectional view shows the patented construction of Hannifin double acting Hydraulic Cylinders. Note the simple, compact, and rugged construction . . long bearing surfaces . . . full 4-ring piston construction.



ASK FOR A COPY OF THIS NEW BULLETIN

Get your copy of Hannifin's new "Hydraulic Cylinder Bulletin" containing 52 pages of useful specification and engineering data, complete with illustrations and dimensions. Ask for Bulletin No. 110-M.

- **SUPERIOR DESIGN.** An improved type of high pressure hydraulic cylinder. Universal end caps for easy installation and simplified piping . . . tight sealing, precision type honed piston rings for maximum power, lasting "leakproof" operation. No-tie-rod design.
- **PRECISION CONSTRUCTION.** Cylinder *TRU-BORED* from steel and honed to satin finish by exclusive Hannifin long stroke honing process. Close tolerances between piston and cylinder. Manufactured with precision tooling throughout to insure complete interchangeability of parts.
- **COMPLETE LINE.** 12 standard bore diameters, 1" to 8"... any length stroke you specify...11 standard mounting styles...standard, double end, or heavy duty (2:1) piston rods . . . available with adjustable cushions...pressures to 1500 lbs. per sq. in. Special types built to order.
- **ENGINEERING RECOMMENDATIONS.** Let Hannifin engineers help you get the BEST solution for your hydraulic cylinder problems. Recommendations backed by more than forty years of specialized engineering experience. See your local Hannifin representative, or write.

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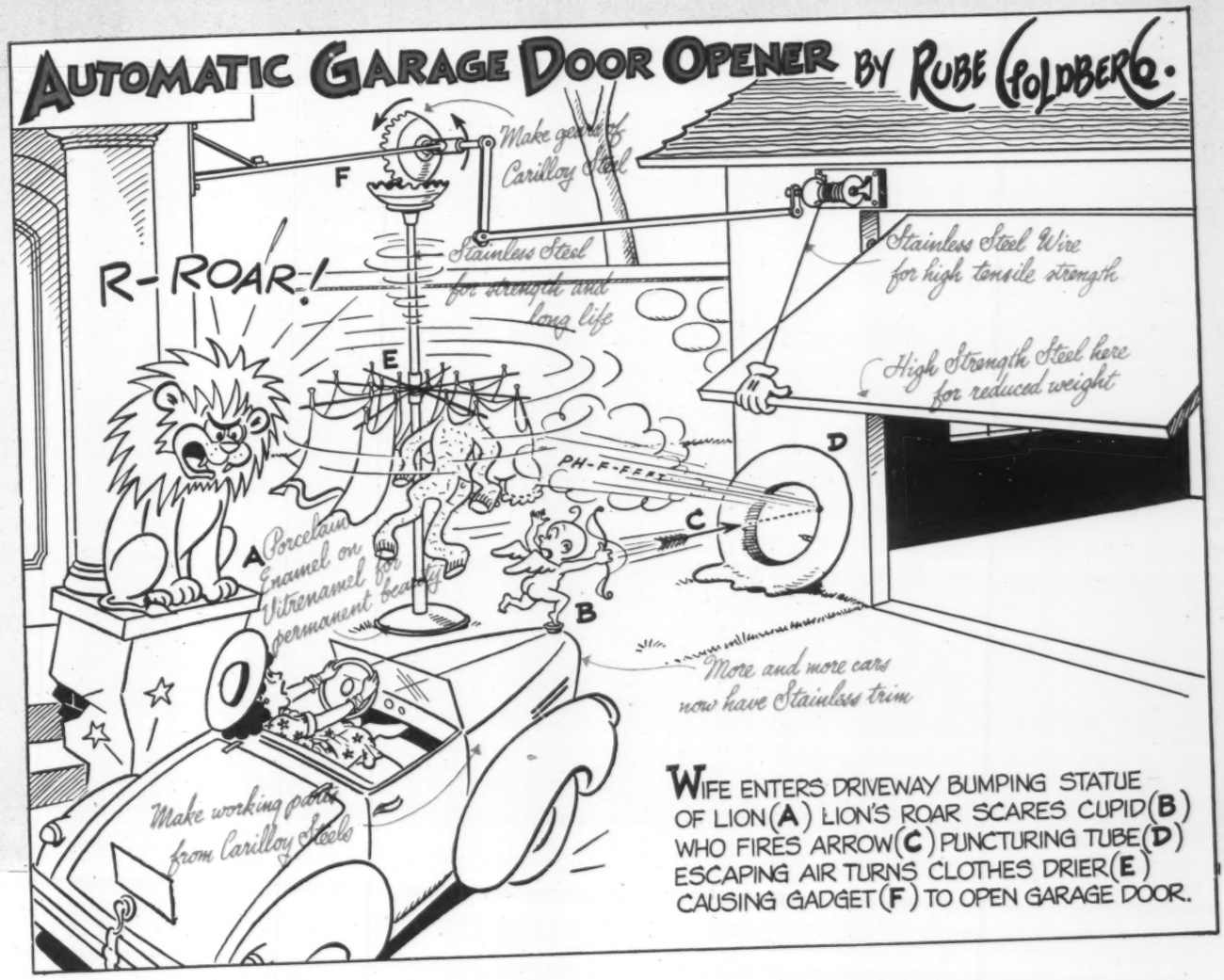

WHILE Mr. Goldberg's suggestion for an automatic garage door opener may still need a little polishing, it *does* point out a significant fact to the design engineer . . . namely, that nine times out of ten, steel will do a better job. There are steels to withstand the severest range of temperatures; steels to resist shock, corrosion, severe bending and abrasion.

Steel has toughness for lightweight construction. It can be welded to perfection, riveted, punched. It can be polished to mirror surface . . . etched, painted or permanently coated with porcelain enamel. It can be drawn, formed, forged, cast, machined on a mass production basis.

Not only is steel the most versatile of materials, but when it is judged on the basis of performance, its economic superiority is outstanding.

To help you with your design problem—to give your product the many desirable properties that steel can contribute—the nation's largest organization of specialists in steel is ready to assist you.

CARNEGIE-ILLINOIS STEEL CORPORATION
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COLUMBIA STEEL COMPANY, San Francisco, Pacific Coast Distributors
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7-559

Have you explored the possibilities of these special purpose U·S·S Steels?

U·S·S STAINLESS AND HEAT-RESISTING STEELS to assure high resistance to corrosion and heat, and to reduce weight.
U·S·S CARILLOY STEELS—Alloy steels for the special jobs of industry.
U·S·S HIGH STRENGTH STEELS to resist atmospheric corrosion, to increase strength without adding weight or to maintain strength with reduced weight.
U·S·S COPPER STEEL to give at least twice the atmospheric corrosion resistance of regular steel at little additional cost.
U·S·S ABRASION-RESISTING STEEL to combat wear and friction.
U·S·S HOT-ROLLED AND COLD-ROLLED STEELS to provide the basic advantages of steel, plus maximum economy in each job.
U·S·S PAINTBOND—A galvanized, Bonderized sheet that permits immediate painting and holds paint tighter.
U·S·S VITRENAMEL—Sheets designed especially for porcelain enameling.
U·S·S ELECTRICAL SHEETS for motors, generators and transformers.

9 times out of 10 STEEL will do it better

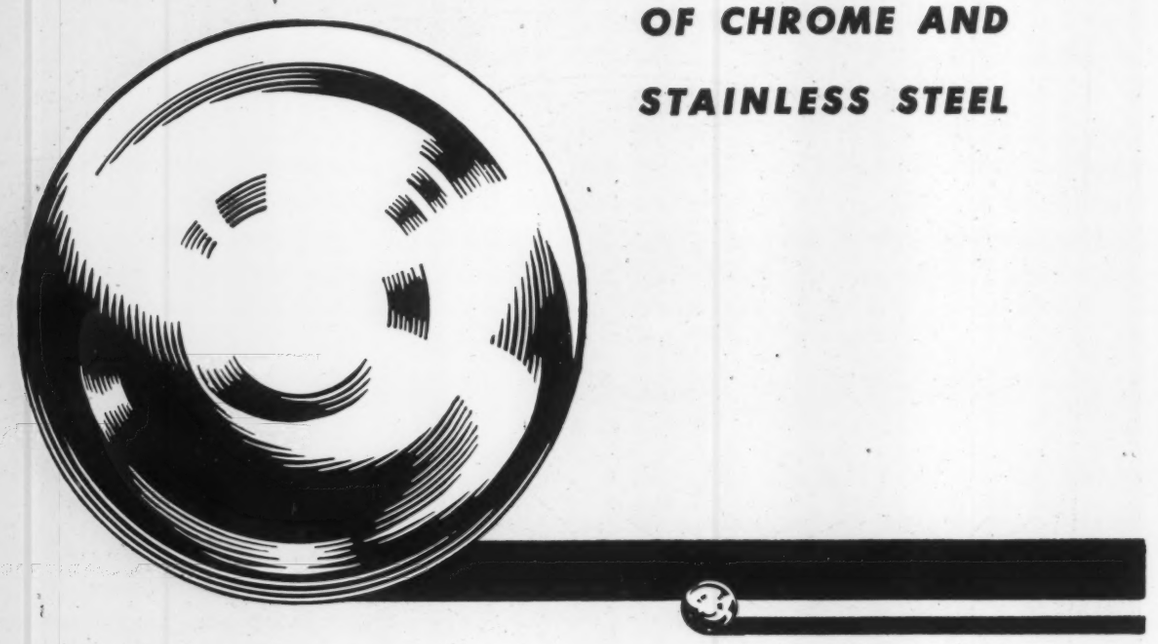
USS STEEL UNITED STATES STEEL

IT TAKES SCRAP TO MAKE STEEL . . . PLEASE TURN YOURS IN!

UNITED STATES STEEL

PRECISION BALLS

OF CHROME AND STAINLESS STEEL



Ready for your 1947 production schedules. Chrome and Stainless Steel precision balls of unexcelled quality.

For prompt delivery, telephone, telegraph or write, giving sizes required and application.

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UNIVERSAL BALL CO.

(A MODERN PRECISION BALL PLANT)

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SUPERIOR ABRASION RESISTANCE

Parts made from HYCAR synthetic rubber have 50% greater abrasion resistance than parts made from natural rubber. That means they'll last longer, give more dependable performance in the most severe service, and save maintenance and replacement time.

But that's only one of HYCAR's unusual and valuable properties. Examine the list in the box at the right. Think of these properties in terms of your requirements of rubber parts. Realize that these properties may be had in an almost limitless number of combinations, each designed to meet the specific service conditions of the finished part.

We have developed more than 5000 recipes for HYCAR compounds — each compound engineered to do a certain job. If you're looking for rubber parts that will give long life, dependability, and economical operation, *specify HYCAR.*

Ask your supplier for parts made from HYCAR. Test them in your own applications, difficult or routine. You'll learn for yourself that it's wise to use HYCAR for long-time, dependable performance. For more information, please write Department HN-3 B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio.

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1. *EXTREME OIL RESISTANCE — insuring dimensional stability of parts.*
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9. *NON-ADHERENT TO METAL—compounds will not adhere to metals even after prolonged contact under pressure. (Metal adhesions can be readily obtained when desired.)*

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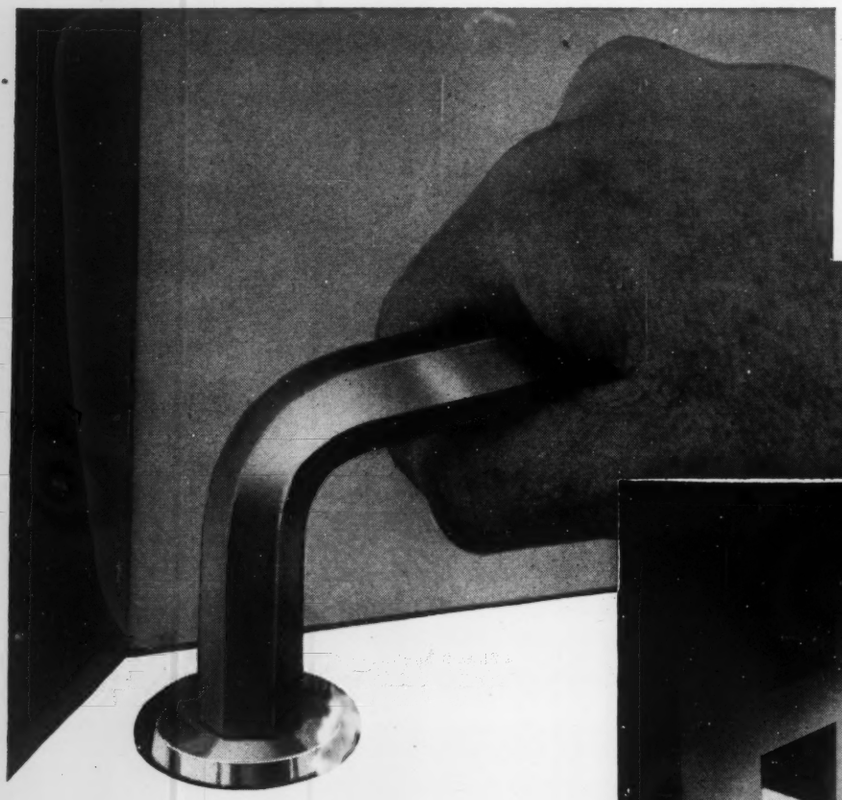
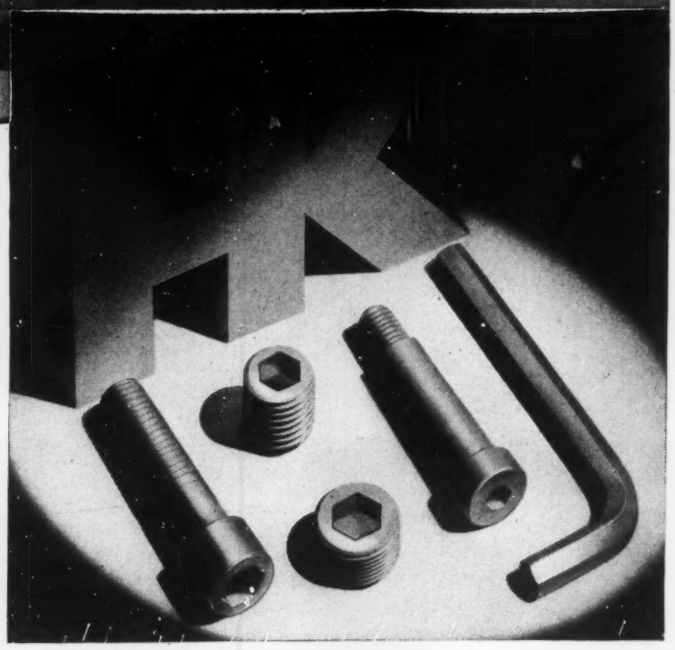


To SAVE TIME!



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...QUICK AND POSITIVE TIGHTENING

THE BETTER FASTENING METHOD

On production assembly — simple or intricate fastening jobs — Holo-Krome Fibro Forged Socket Screws, the Completely Cold Forged Screws made from special analysis alloy steel and scientifically heat treated, are speeding up assembly because of their Internal Wrenching feature. Holo-Krome Keys fit quickly into the Completely Cold Forged sockets and positive tightening is assured . . . All Holo-Krome Socket Screw Products are guaranteed to give Unfailing Performance . . . Specify "Holo-Krome." The Holo-Krome Screw Corp. Hartford 10, Conn. U.S.A.

HOLO-KROME
fibro forged SOCKET SCREWS

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SOCKET HEAD CAP SCREWS — SOCKET SET SCREWS — SOCKET HEAD STRIPPER BOLTS — SOCKET PIPE PLUGS — SOCKET SCREW KEYS AND SOCKET SCREW KEY SETS . . .

•

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YOU GET METAL QUALITY DEVELOPED FULLY IN *Forgings*

PLUS THESE 7 ADVANTAGES

1. ***High tensile and impact strength*** obtained through controlled concentration of grain structure and fibre-like flow lines.
2. ***A correctly proportioned combination*** of physical properties to meet a specific service condition.
3. ***Reduction of dead weight;*** maximum strength and toughness in lighter sectional thicknesses.
4. ***Reductions in cost*** at point of assembly due to less time required to machine and finish, and fewer rejects.
5. ***Rapid assembly*** of complex parts by welding, because forgings provide welding adaptability of widest range.
6. ***A reduction of accidents*** to men and machines, because forgings provide a greater margin of safety.
7. ***Controlled concentration*** of fibre-like flow line structure of metal at points of greatest shock and stress.

● In forgings, metal quality can be developed to the exact degree required to meet a specific service condition *when the design utilizes the fibre-like flow line structure inherent in wrought metals.* The illustrations show how maximum tensile and impact strength, toughness and fatigue resistance have been obtained in a wide variety of shapes and sizes of forgings. Forgings reduce part failures and protect you and your customer from unpredictable emergencies. A re-check of every stressed part, as well as simple handles and levers, often reveals opportunities to improve the performance of a product, to reduce cost of machining and finishing, to speed up assembly. Consult a forging engineer while the part is in the design stage. He will show you how to obtain the maximum metal quality required for a specific service condition and acquaint you with new forging techniques that are available now for the production of many so-called "impossible-to-forge" designs.

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More and steadier output per machine is the surest means of coping with continued high demand. Better drives—Diamond Chain Drives—can help you to maintain exact speed ratios and maximum output continuously.

Gains of 2 to 10 per cent in output are reported by one industry that has converted almost entirely to Diamond Drives. Such gains can well be the difference between profit and loss.

Diamond Roller Chain Drives neither slip nor creep—they are practically as efficient (98-99%) after years of service as when new—and operate smoothly and quietly at all speeds . . . They are the choice of the country's leading machinery manufacturers . . . Now is the time to consider *your* machinery drives for better output and higher efficiency.

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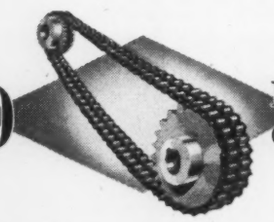
All Principal Cities.



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The drive data in our 96-page Bulletin 617 will help you. A copy is yours for the asking.

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WHERE DIAMOND VULCANIZED FIBRE FITS INTO PRODUCT DESIGN . . . . .

There is no end of profitable applications for this versatile material. It is used in a multitude of mechanical, structural and electrical applications because of its unique combination of lightweight, strength, toughness, resistance to wear and abrasion, excellent arc-resistance and good dielectric properties.

Diamond Vulcanized Fibre is available in sheets, rods and tubes which are easily and cleanly fabricated on woodworking or metalworking machinery. It can be formed and punched; cut and sawed; drilled and tapped; turned, threaded and reamed . . . or, if you wish, we can supply the parts you need fabricated to your specifications.

Long experience in fibre application engineering, in connection with our complete line of laminated (Dilecto) and molded (Celoron) plastics, enables us to render unbiased recommendations for the best application of fibre to the solution of your mechanical and electrical problems. Just call in a Continental-Diamond Technician—or write for your Continental-Diamond Fibre catalog.

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DIAMOND VULCANIZED FIBRE

VULCOID—Resin Impregnated Vulcanized Fibre.

DILECTO—Thermosetting Laminated Plastics.

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Available in Standard Sheets, Rods and Tubes; and Parts Fabricated, Formed or Molded to Specifications.

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Bulletin GF gives Comprehensive Data on all C-D Products. Catalogs are also available.

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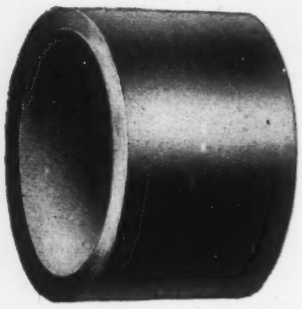
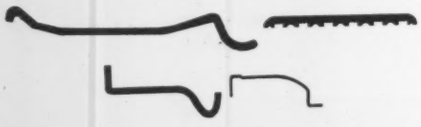


Typical Cross Sections



Our equipment enables us to furnish many diameters and widths of sections.

Note that this method requires *production* quantities.

RING WELDMENTS

One way to reduce your production costs may be the use of ring weldments such as those shown here. The Cleve-Weld method of producing circular shapes in quantity lots has cut costs for others—perhaps it is the solution you want.

Specialized equipment and background experience at Cleve-Weld produce rings from flat stock or hot rolled mill sections. The material is shaped into hoop form; welded together, then rolled to the specified cross-section, holding required tolerances.

The resulting piece represents less fabricating time and generally is achieved with less weight of raw material and reduced time for finishing. Frequently, *all* machining is eliminated. You may find your answer at Cleve-Weld. Just send a print of sketch, with details of quantity and material required. We will answer promptly with estimates—no obligation on your part. Just try us.

THE CLEVELAND WELDING COMPANY
West 117th Street & Berea Rd. • Cleveland 7, Ohio

Small-Motor Answers To Streamlined Designing

Step up the *sales appeal* of your motor-driven products, and *cut costs*, too, with modern, functional design. You'll find Robbins & Myers fractional horsepower motors the *key* to outstanding performance and smooth appearance in built-in power.

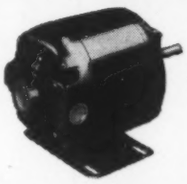
R & M MOTORS SIMPLIFY CONSTRUCTION

Whatever your specific requirements, you can gain through R & M's long experience in building small motors for widely diversified uses. Standardized R & M mountings and mechanical features help make built-in electric power both economical and practical. *Full interchangeability* of all motor types in any one frame size simplifies design, application, and assembly. AC, DC, or Universal motors fit into the same machine without any modification of construction or appearance.

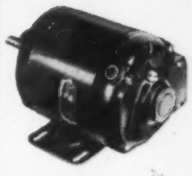
MANY MOTOR TYPES; MANY SIZES

Production types of R & M fractional horsepower motors are described briefly below. Construction details, dimensions, and performance data on these and other R & M motors furnished without obligation.

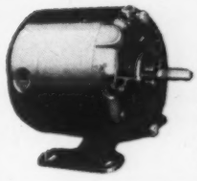
TYPICAL TYPES—ROBBINS & MYERS FRACTIONAL-HORSEPOWER MOTORS



RESISTANCE SPLIT-PHASE
1/20 to ⅓ H.P.
High starting torque and constant speed. Low starting current. Uses simple, sturdy centrifugal switch. Built-in terminal box, with toggle line switch and overload protection optional. Economical. Bulletin 600.

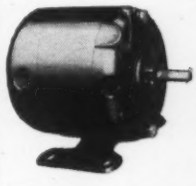


DIRECT CURRENT
1/20 to 1 H.P.
Quiet, efficient shunt-wound motors with excellent starting torque. Heavy-duty commutator and brushes. Variable speed control, if desired. Built-in terminal box; toggle switch and overload protection optional. Bulletin 603.

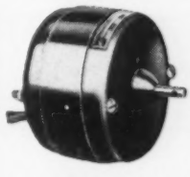


CAPACITOR
1/200 to 1/20 H.P.
Permanent-split capacitor motor has high efficiency, adjustable speed; is easily reversed. Low starting torque. No brushes, commutator, or centrifugal switch. Quiet, smooth operation. Bulletin 10C.

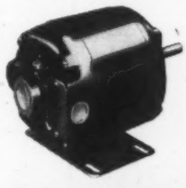
CAPACITOR-START
⅛ to 1 H.P.
Greater starting torque than comparable resistance split-phase type. Uses electrolytic capacitor during starting period only. Built-in terminal box, with toggle switch and overload protection optional. Bulletin 601.



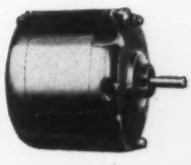
UNIVERSAL & DC
1/200 to 1/12 H.P.
Wound-armature design, with commutator and brushes. Universal motor can be used on various frequencies, AC, or on DC; speed varies with load. Shunt-wound DC models give more constant speed. Bulletin 108.



SYNCHRONOUS
1/200 to 1/20 H.P.
Self-starting reluctance type, similar in construction to permanent-split capacitor motor. Absolutely constant speed operation. Hysteresis type for special applications is super-quiet, vibrationless. Bulletin 10C.



POLYPHASE INDUCTION
⅙ to 1 H.P.
Constant speed operation with high starting torque. Simple, rugged construction; squirrel-cage rotor—no centrifugal switch required. Built-in terminal box. Widely used for industrial applications. Bulletin 604.



SHADED POLE
1/200 to 1/20 H.P.
Available in high or normal starting torque models; for light or standard service. No brushes, commutator, or centrifugal switch. Non-reversible. Low cost. Reactance type speed control optional. Bulletin 10A.

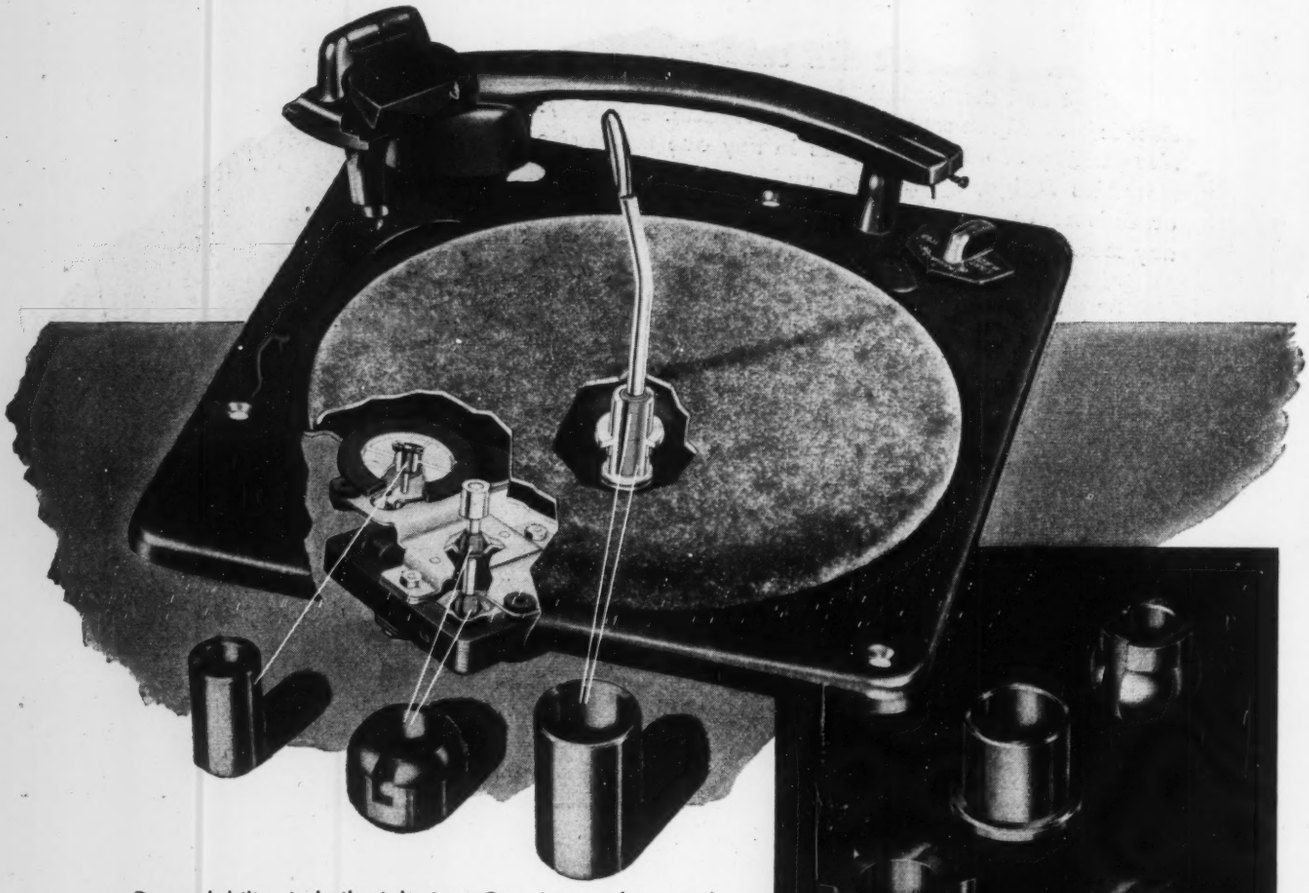
MATCHED MOTOR PARTS
1/100 to 1½ H.P.
R & M precision motor parts enable manufacturers of electric power-driven equipment to make the motor an integral part of their product. All types and sizes, specifically engineered to your requirements. Bulletin 1871.

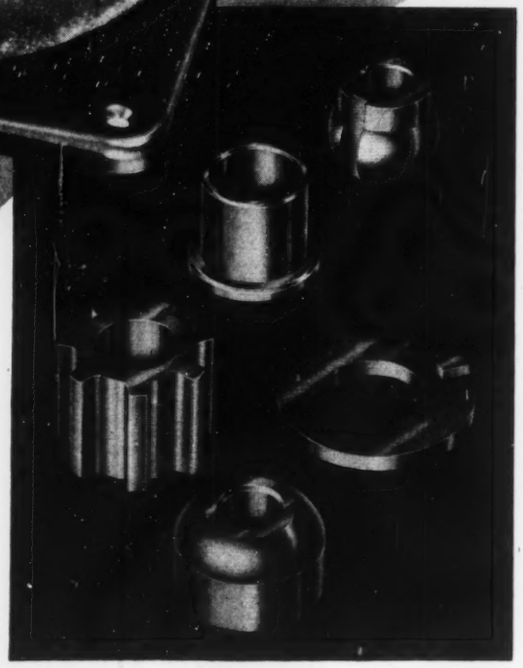
ROBBINS & MYERS • INC. MOTOR DIVISION • SPRINGFIELD, OHIO
In Canada: Robbins & Myers Co., of Canada, Ltd., Brantford, Ont.

MOTORS • HOISTS • CRANES • MACHINE DRIVES • FANS • MOYNO PUMPS • FOUNDED 1878

gramix bearings assure smooth, uninterrupted performance for Webster-Chicago automatic record player

The modern Casey and his hep-cat blonde can waltz or jitterbug to their hearts' content, thanks to Webster-Chicago Corp. and Gramix. This Webster-Chicago automatic record player depends upon Gramix powder metal bearings for smooth, flawless performance in playing and changing a dozen records in succession. Installed as shown, the two cylindrical Gramix bearings assure the constant turntable speed that means high fidelity reproduction of recorded music; and the two self-aligning and one cylindrical Gramix bearings help keep the record changing mechanism operating without a hitch. With such dependability, it's no wonder this Webster-Chicago unit is one of the big leaders in the record changer field.





Dependability is built right into Gramix powder metal parts. They are die-pressed of powdered metal—to close-tolerance size, with perfect bearing and sliding surfaces that require no costly machining, and to desired porosity that permits impregnation with lubricant so that further lubrication is often unnecessary. They cost less, they last longer. Send us sketches or descriptions of your products. Our engineers will show you where Gramix bearings, washers, small gears, or other powder metal parts may improve mechanical performance and save you money. Write ***today*** for your copy of the big, new, 260 page GRAMIX catalog.

gramix

THE UNITED STATES GRAPHITE COMPANY • SAGINAW, MICHIGAN

Never before so simple!

No, never before has any large-volume printer-developer offered such *simplicity* in making direct-line process reproductions of your engineering drawings in ink or pencil—office forms—specifications—bulletins, etc. One operator, using this new Bruning Volumatic, can produce prints in seconds from translucent or transparent originals—in unlimited quantities—on cut sheets or roll stock. Compactly designed, the Volumatic can be installed anywhere—requires no plumbing, produces no irritating fumes which must be exhausted. Mail the coupon for complete information.

BRUNING

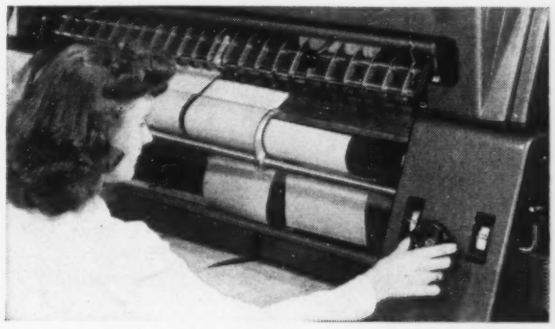
CHARLES BRUNING COMPANY, INC.

Since 1897

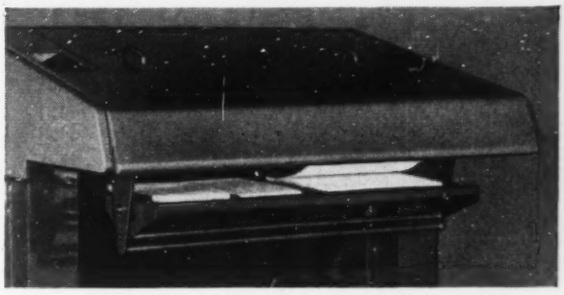
NEW YORK • CHICAGO • LOS ANGELES

Atlanta • Boston • Cleveland • Detroit • Houston • Kansas City
Milwaukee • Newark • Pittsburgh • St. Louis • San Francisco • Seattle

LARGE VOLUME PRODUCTION is handled with amazing ease on the Bruning Volumatic. The feedboard provides approximately 13 square feet of area for stacking unexposed BW cut sheets and the originals to be reproduced. You can have black or colored line BW paper prints on white backgrounds—light, regular or card-weight BW Prints—black or colored line prints on green or pink tinted backgrounds—cloth prints—transparent paper or film prints!



NO CONFUSING GADGETS on the Volumatic! The few controls necessary are simple in operation and are always within easy reach of the operator. Illustration shows the speed control knob which enables the operator to change instantly to any printing speed from 0 to 30 feet per minute, consistent with the type of original being reproduced. Efficient exposure is provided by a stationary 3450 watt high pressure mercury vapor arc lamp.



READY FOR USE, prints are automatically stacked on a convenient tray at the rear of the Volumatic. When roll stock is used, a simple adjustment of the stacking tray directs printed roll stock to your trimming table. With the Volumatic, you are sure of getting uniformly developed prints at all speeds—easy-to-read direct-line process prints, far more useful than blue prints.

CHARLES BRUNING COMPANY, INC.

[illegible] this is

Gentlemen: I want to know more about Bruning BW Prints and equipment. Please send me information.

Name.....

Company.....

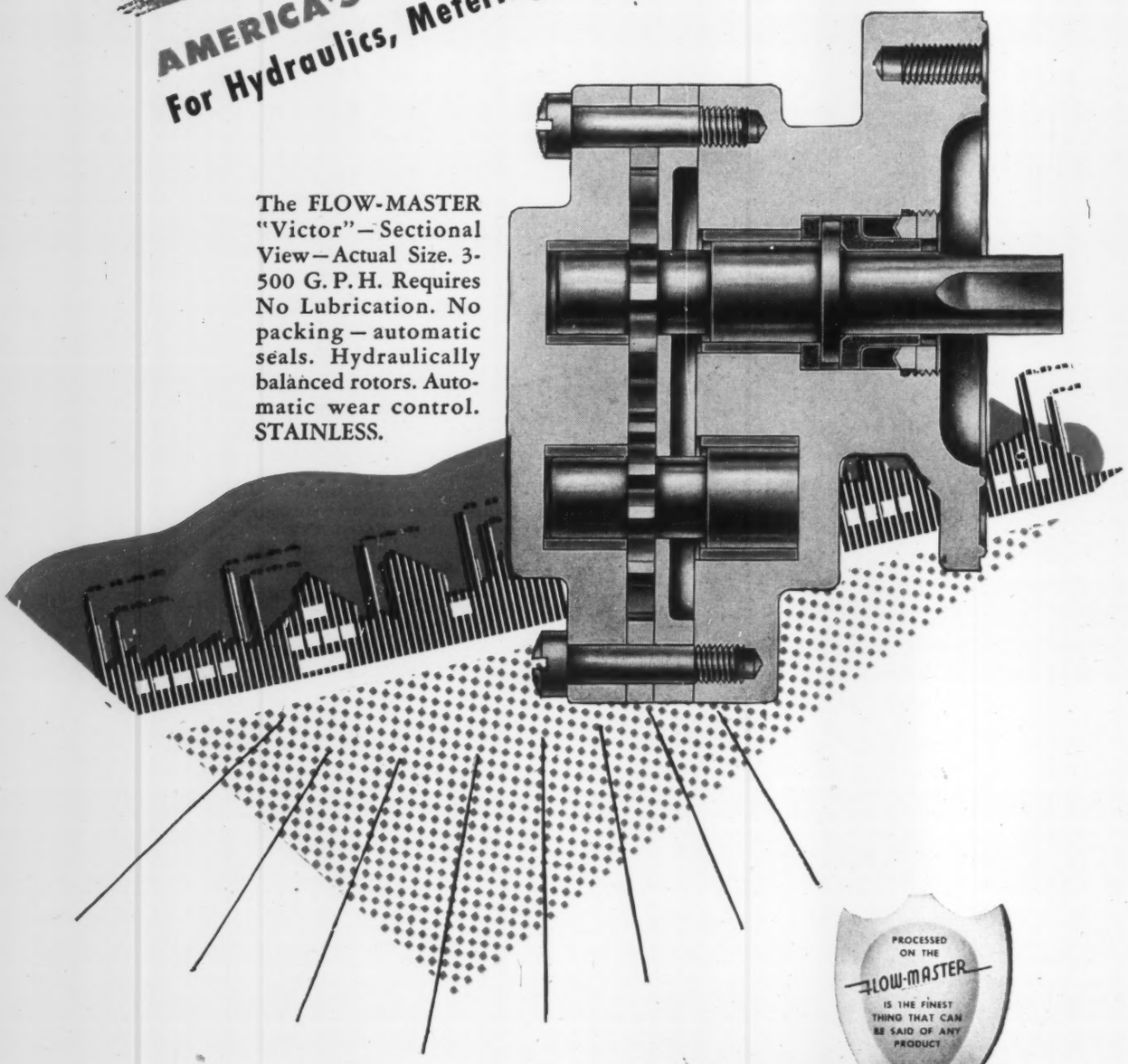
Street.....

City.....*State*.....

FLOW-MASTER "Victor"

AMERICA'S NEWEST, FINEST SMALL PUMP
For Hydraulics, Metering, Proportioning, Transferring

The FLOW-MASTER "Victor"—Sectional View—Actual Size. 3-500 G. P. H. Requires No Lubrication. No packing—automatic seals. Hydraulically balanced rotors. Automatic wear control. STAINLESS.



FLOW-MASTER **Pumps—Homogenizers**
Kom-Bi-Nators
Equipment For The Process Industries

MARCO COMPANY Inc. Wilmington 50, Del.

It's UNIFORMITY that counts in a free cutting rod

Uniformity of dimension, shape and surface smoothness are readily evident in a free cutting rod. Not so obvious, however, but far more important to the manufacturer of screw machine products, are those desirable but unseen characteristics; uniform *composition,* uniform *temper* and uniform *metal structure*. For on these depend the physical properties of the part, the excellence of its machined finish, and the economy of its production through sustained high cutting speeds.

The American Brass Company produces a large number of Anaconda Copper and Copper Alloy Rods in all commercial sizes and shapes suitable for screw machine use. Sixteen are free cutting alloys. The "special purpose" properties of six of these are indicated on the following page. 47113

THE AMERICAN BRASS COMPANY

General Offices: Waterbury 88, Connecticut

Subsidiary of Anaconda Copper Mining Company

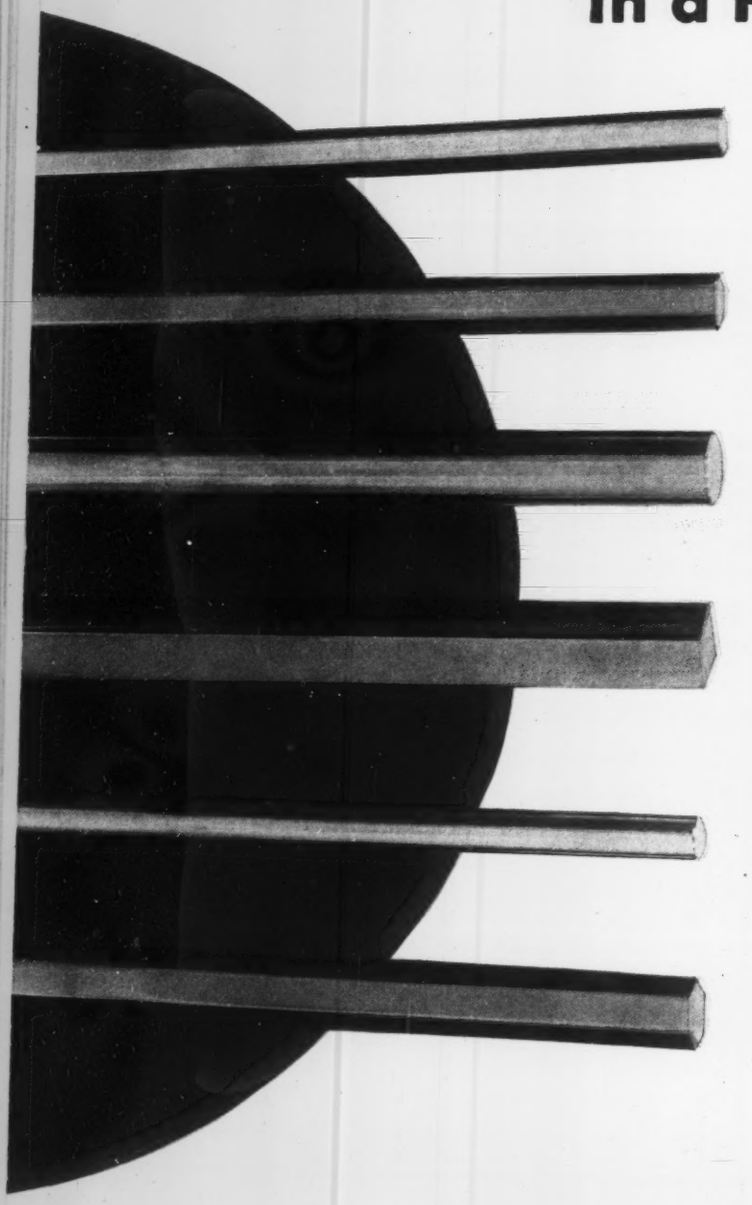
In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

ANACONDA

from mine to consumer

Anaconda **FREE CUTTING RODS**

What do you need most in a FREE CUTTING ROD



- **Maximum Machinability?** Free Cutting Yellow Brass 271. The standard all-purpose rod of the screw machine industry; economical, versatile, ranking highest in machinability.

- **High Electrical Conductivity?** Leaded Copper 946. A truly free cutting copper rod having a minimum electrical conductivity of 95% I.A.C.S. in commercial hard temper.

- **Good Bearing Qualities?** Special Free Cutting Phosphor Bronze 610. Combines typical "phosphor bronze" bearing qualities with machinability close to that of yellow brass.

- **High Strength and Toughness?** Everdur* 1012. This rod provides the toughness, high strength and corrosion resistance of copper-silicon alloys with ready machinability. *Reg. U.S. Pat. Off.

- **A Ductile, Silvery White Alloy?** Leaded Nickel Silver 12% 796. Strong, tough and durable, this silvery white alloy is free cutting, yet ductile enough in proper temper to permit cold forming or spinning.

- **High Resistance to Corrosion Cracking?** High Strength Commercial Bronze 286. A relatively new Anaconda Rod combining high strength (70,000 lb. per sq. in. commercially hard drawn, up to 1") with excellent machinability and unusual resistance to corrosion cracking.

Compositions, physical properties, constants and machinability ratings of all Anaconda Free Cutting Rods are listed in Publication B-14. Practical suggestions for machining copper and copper base alloys are included in Publication B-3. Either one or both will be mailed on request.

Chips machined without coolant from High Strength Commercial Bronze 286. Depth of cut, .375"; feed, .003". Illustration two-thirds scale.

THE AMERICAN BRASS COMPANY

General Offices: Waterbury 88, Connecticut

Subsidiary of Anaconda Copper Mining Company

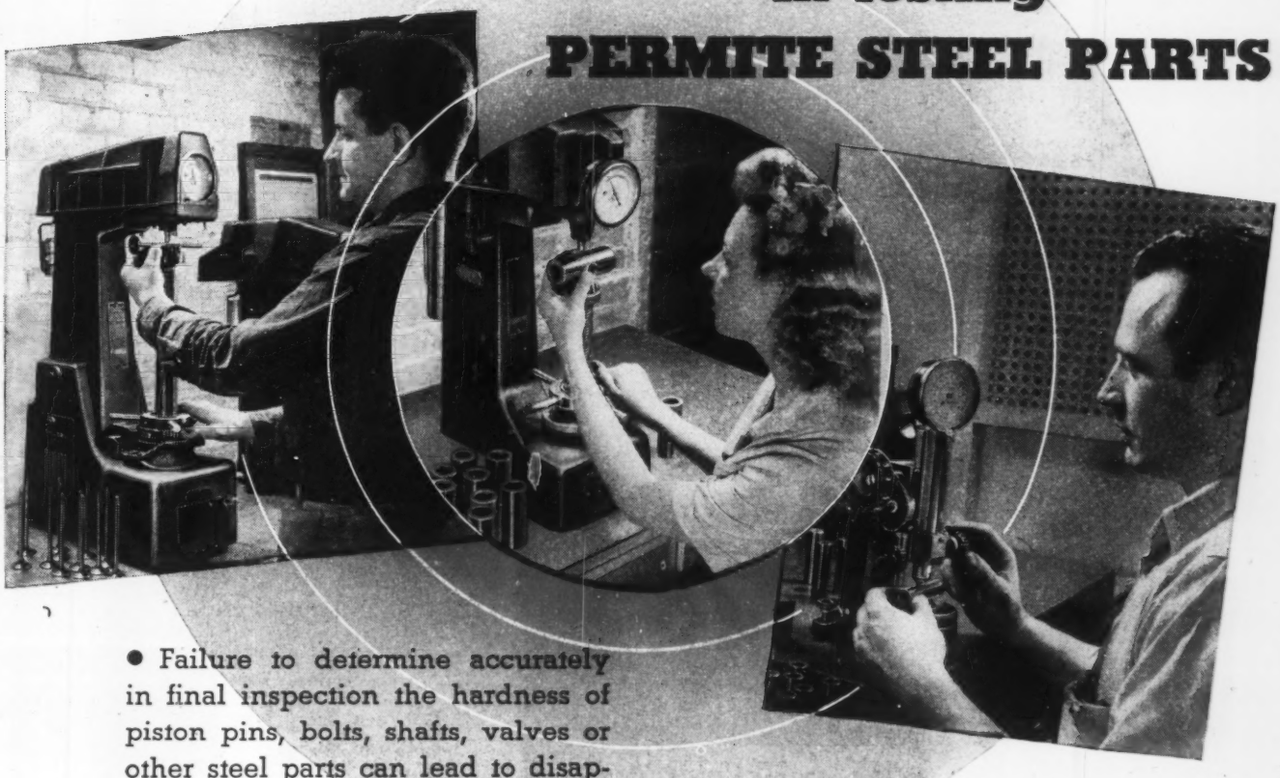
In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

ANACONDA from mine to consumer

Anaconda **FREE CUTTING RODS**

HOW HARD IS HARD?

How Permite Insures the RIGHT ANSWER in testing PERMITE STEEL PARTS



• Failure to determine accurately in final inspection the hardness of piston pins, bolts, shafts, valves or other steel parts can lead to disappointing wear resistance in service.

So Permite quality control brings into use three different machines for testing hardness of Permite Steel Parts—the Rockwell Standard Hardness Testing Machine, which determines surface hardness by the depth of penetration of the diamond point; the Superficial Rockwell, which penetrates to a lesser depth so as to avoid piercing the extremely thin case-hardened parts; and the Scleroscope, which tests by a rebound operation that does not mar or mark the part.

This hardness testing procedure is an example of the quality control governing every step in the production of all Permite Steel Parts, to insure longer life and better performance. Permite engineers will gladly consult with you regarding your steel parts requirements.

PERMITE

ALUMINUM INDUSTRIES, INC.

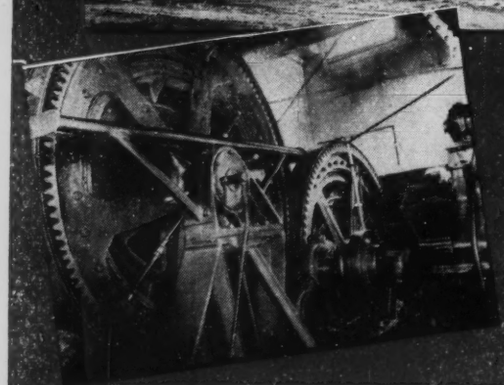
CINCINNATI 25, OHIO

DETROIT: 809 New Center Building. NEW YORK: 9 Rockefeller Plaza. CHICAGO: 64 E. Jackson Boulevard. ATLANTA: 413 Grant Building.

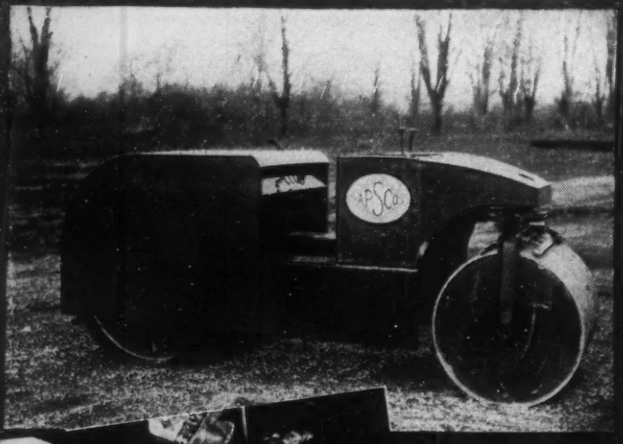
ALUMINUM PERMANENT MOLD, SAND and DIE CASTINGS...HARDENED, GROUND and FORGED STEEL PARTS

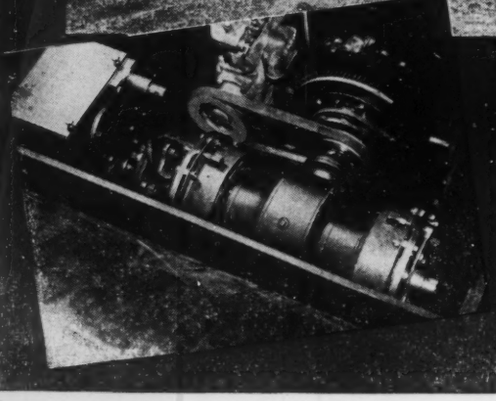
For ANY heavy duty service

USE FAWICK CLUTCHES



This 350-ton, 8 yard Marion drag line equipped with Fawick 84" drag-drum clutch and 60" Fawick hoist drum clutch.





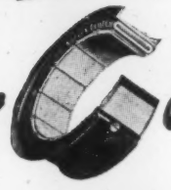
3 to 4-ton tandem roller, made by All-Purpose Spreader Co., equipped with Fawick 6" drive clutches.

Here are the moneysaving advantages of the Fawick Airflex Clutch for all types of heavy-duty clutch service:

1. Torque controlled and shocks absorbed by a cushion of air.
2. No strain on any part of machine in quick starts and stops under load.
3. No arms, lever or springs to wear or break.
4. No adjustments to make—no lubrication required.
5. Maintenance costs unusually low.
6. Entire machine protected against needless loss of productive time.

Let our Engineering Department give you our recommendations.

FAWICK

Air  *flex*

CLUTCH

FAWICK AIRFLEX COMPANY, INC.
9919 Clinton Road • Cleveland 11, Ohio

In Canada, Renold-Coventry Ltd., Montreal, Toronto, Vancouver
In Britain, Crofts Engineers, Ltd., Bradford, England

How Riverside Nickel Silver Helps Add Years To The Life of Your RONSON Lighter

Riverside Nickel Silver is used in the fabrication of many essential parts of Ronson lighter products exposed to wear such as the shell and segments.

Special Note—A Ronson Lighter can't stay lit as shown on cake. "Press, it's lit—Release, it's out, the instant you lift your finger."

A good lighter is a most useful and efficient possession. But lighters are subject to severe abuse. Lighter manufacturers must take this fact into consideration and buy materials of the highest quality, to build lighters that will give uninterrupted service over a long period of years.

The makers of Ronson, one of the world's truly great lighters, use Riverside *Nickel Silver* to fabricate many essential parts (see above) exposed to wear. (Many of the Ronsons made more than twenty years ago are still giving unfailing service.) Riverside *Nickel Silver* is silvery white clear-through and, as the years pass by, its bright lustre does not wear off. It has an excellent surface for plating or polishing and readily takes a fine damaskeen-type finish.

Riverside *Nickel Silver* is tough, resistant to wear, fatigue and corrosion but easy to machine in any manner and weldable by all methods. It is extremely workable and can be formed, bent, drawn, stamped, punched, embossed or spun.

You may be able to improve your product with Riverside *Nickel Silver* or with Riverside's other alloys; *Phosphor Bronze* and *Beryllium Copper*. Our metallurgists are ready to help you. Write for information and catalogs.

INSIDE RIVERSIDE—*We not only say we are flexible in our thinking and operations; we have the alloys to prove it. Fifty years of supplying non-ferrous metals of a highly specialized nature, to almost every type industry you can name, has kept our minds young, our viewpoint fresh and our metallurgists active solving new problems and improving alloys. Tell us about your coming requirements, large or small. We think you'll like the way we tackle a job.*

RIVERSIDE

THE RIVERSIDE METAL COMPANY

NEW YORK CHICAGO RIVERSIDE • NEW JERSEY HARTFORD CLEVELAND

O.K. of a Great Critic...

A WHOLE PLANTFUL OF THEM WHO BUILD MOTORS TO SATISFY EXACTING BUYERS!

● Other plants may turn out *more* motors than the Star Plant. But you'll find no *better* motors ... for when you see the Star Trademark you see the "O.K." on the efforts of hundreds of meticulous craftsmen working to critical standards.

Among them are the men who own the company. For Star's principals are born motor men, and the place to find them is out in the plant or around a drawing board, helping to make Star Motors as good as they can be.

Everybody at Star is exacting about quality ... in design, materials, workmanship. There's a craftsman's spirit everywhere that words can't cover. But motor buyers who visit us always comment on it. And exacting motor users recognize that Star does things a bit better. That's why they specify Star where a motor must be better than "good enough".

WRITE FOR 8-PAGE DIGEST. It outlines Star Motors (½ to 200 HP) and Generators (to 150 KW) . . . names hard-to-satisfy buyers who are long-time customers . . . tells how Star becomes the "Motor Department" for customers. Star Electric Motor Co., 200 Bloomfield Ave., Bloomfield, New Jersey.

STAR MOTORS

POWER PACKAGED AS YOU NEED IT

MULTIPLE *Fastener Protection* PLUS ASSEMBLY LINE ECONOMIES

AT THESE POINTS:

1—Body-Hold-Down
2—Gas Tank Strap
3—Accelerator Treadle Hinge
4—Hood Operating Arm
5—Radiator Brace Rod
6—Glove Box Check Arm

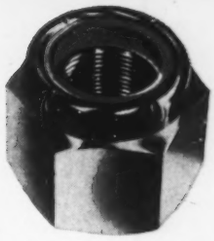
WILLYS-OVERLAND 'JEEP' STATION WAGON

—*with the Self-Locking, Self-Sealing and Reusable Red Elastic Collar*

Willys-Overland's new 'JEEP' Station Wagon has a world-wide reputation for stamina, performance and economy. So here again, self-locking ESNA Elastic Stop Nuts have been applied at six tough detachable fastener assembly points to lock out body squeaks and rattles... maintain alignments... permit easy removal and replacement for servicing. And further, to reduce assembly line costs with a one-piece, self-locking fastener that can be quickly run-on with a power tool.

All ESNA Elastic Stop Nuts—with the self-locking, self-sealing and reusable Red Elastic Collar—provide dependable protection against Vibration, Impact and Stress Reversal in both prestressed and positioned settings.

In addition, they protect against Thread Corrosion, Thread Failure and Liquid Seepage. This multiple protection helps achieve the double economy of inventory simplification and reduced procurement costs. ESNA engineers are ready to study your fastener problems. Address: Elastic Stop Nut Corporation of America, Union, New Jersey. Sales Engineers and Distributors are conveniently located in many principal cities.



LOOK FOR THE RED COLLAR
THE SYMBOL OF SECURITY

It is threadless and dependably elastic. Every bolt—*regardless of commercial tolerances*—impresses (does not cut) its full thread contact in the Red Elastic Collar to fully grip the bolt threads. In addition, this threading action properly seats the metal threads—and eliminates all axial play between bolt and nut.

All ESNA Elastic Stop Nuts—*regardless of size or type*—lock in position anywhere on a bolt or stud. Vibration, impact or stress reversal cannot disturb prestressed or positioned settings.

ELASTIC STOP NUTS

INTERNAL WRENCHING

ANCHOR

WING

SPLINE

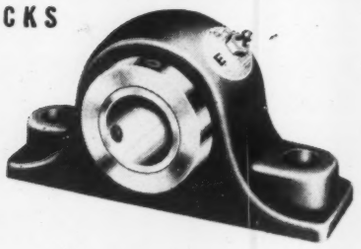
CLINCH

GANG CHANNEL

CAP

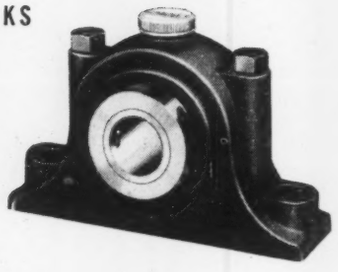
PRODUCTS OF: **ELASTIC STOP NUT CORPORATION OF AMERICA**

DODGE-TIMKEN TYPE "E" PILLOW BLOCKS



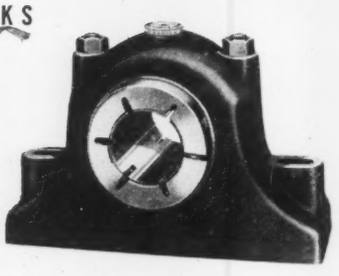
Superior performance at moderate cost. High speed capacity. Sizes 1-3/16" to 4".

DODGE-TIMKEN DOUBLE INTER-LOCK PILLOW BLOCKS



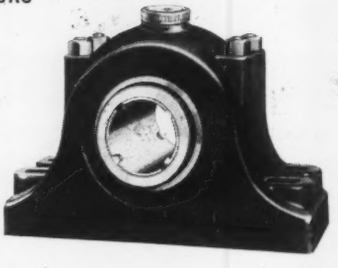
For general service. Normal radial, thrust and shock loads. 1-7/16" to 4-15/16".

DODGE-TIMKEN TYPE "C" PILLOW BLOCKS



Triple sealed against fine abrasive dust. Shaft sizes are 1-3/16" to 4-15/16".

DODGE-TIMKEN SPECIAL DUTY BALL AND SOCKET PILLOW BLOCKS



Rugged, heavy duty, high speeds. Made in shaft sizes from 1-7/16" to 8".

For Unquestioned Quality—

DODGE-TIMKEN

On anti-friction bearings, these two names are assurance of dependability and performance which enable you to cut costs and increase production. Dodge mounts, seals and houses the precision bearing assemblies and delivers them fully assembled, adjusted and lubricated—ready to lock on the shaft. Parts required for mounting these bearings are manufactured complete in the Dodge factory—from foundry through many precision operations on the latest machine tool equipment. The bearings pictured are from the famous Dodge 30,000 hour line, covering a broad range of industrial bearing requirements, promptly available from distributors' stocks.

DODGE MANUFACTURING CORPORATION • MISHAWAKA, INDIANA

CALL THE TRANSMISSIONEER

your local Dodge distributor, for news of latest developments in power transmission equipment. Look for his name in your classified telephone book under "Power Transmission Equipment."

DODGE

of Mishawaka, Ind.

Copyright, 1947, Dodge Mfg. Corp.

NAME PLATES

FOR YOUR NAME PLATE REQUIREMENTS, WRITE OUR SUBSIDIARY, ETCHING COMPANY OF AMERICA, 1520 MONTANA STREET, CHICAGO 14, ILLINOIS

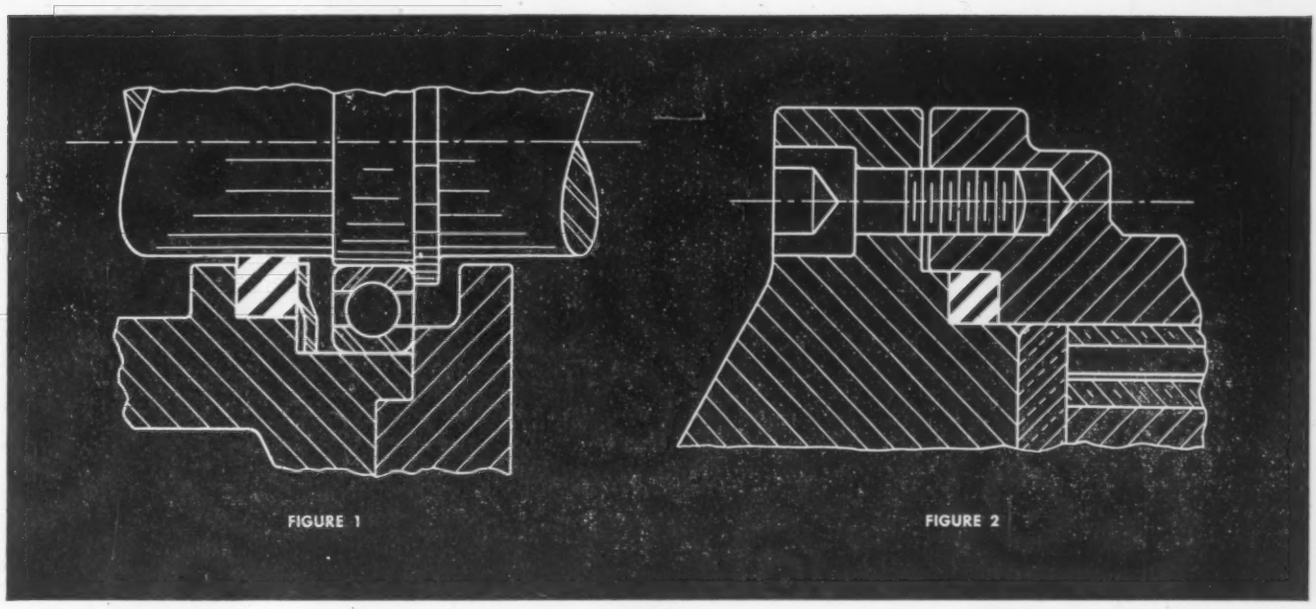


FIGURE 1

FIGURE 2

SEALING ROTARY PUMP SHAFTS EFFICIENTLY

Simple compressible rings are effective and economical

Simple compressible rings provide efficient and inexpensive means of sealing rotary pump shafts. Such rings effectively prevent seepage of air into the pump as well as leakage of the pumped medium. Since this kind of seal does not depend for its effectiveness upon springs, fingers, or other mechanical parts, it is relatively low in cost.

Armstrong's Cork-and-Synthetic-Rubber Compositions make effective ring-type seals. These compositions combine the properties of the various synthetic rubbers with the true compressibility of cork. Under compression, each air-filled cell of cork acts as a self-contained spring. Constant radial pressure is maintained against the shaft without extrusion of the sealing material.

While cork-and-synthetic compositions normally are high-friction materials, scoring and friction losses are easily prevented by a factory-applied lubricant. One lubrication lasts for the life of the seal.

Figure 1, given above, shows the load end of a vane-type pump. This unit is designed to operate with light oil at 1,000 psi, at a maximum temperature of 158° F. Assembled seals had been used on some models and a low-priced composition seal on others. Assembled seals were expensive and called for close assembly tolerances. Composition seals tended to take a permanent set and leaks often resulted.

DC-100, one of Armstrong's Cork-and-Synthetic-Rubber Compositions, now is specified for all models of these pumps. DC-100 prevents aeriation problems as well as loss of pumped fluids. It provides a greater safety factor and gives a more positive seal for a longer period of time. Its compressibility allows the manufacturer to widen his tolerances, thereby effecting machine-time savings. Compressibility also enables this material to absorb lateral compression without extruding in a radial direction.

Figure 2 shows DC-100 used also as a head gasket in the same pump. This material provides a much greater safety factor than the material previously used. Nevertheless, gasket cost is practically the same because gasket volume could be considerably reduced. DC-100 also permits metal-to-metal contact. Thus cumulative tolerances may easily be taken up. Furthermore, since DC-100 is not fragile, this gasket can be re-used if desired when disassembly in the field is necessary.

Because of conditions present in your particular application, DC-100 may not be the material we'd recommend for you. We suggest, therefore, that you discuss your sealing or gasketing problem with an Armstrong Representative when you are designing or redesigning your equipment. He'll suggest suitable materials and provide samples for testing.

If you prefer, send details and working drawings to us for review. You will find our recommendations keyed to good current gasketing practice.

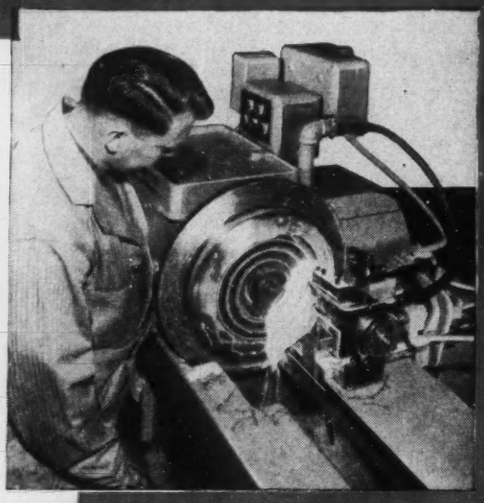
SEND FOR FREE BOOKLET. Write for the new, 20-page 1947 edition of "Armstrong's Gasket and Sealing Materials." It includes specification data on more than 40 of Armstrong's resilient sealing materials and also helpful hints on their proper application. Write to Armstrong Cork Co., Gaskets and Packings Dept., 5107 Arch Street, Lancaster, Pa.

ARMSTRONG'S
GASKETS · SEALS · PACKINGS

Cork Compositions • Cork-and-Synthetic-Rubber Compositions
Synthetic Rubber Compounds • Cork-and-Rubber Compositions
Fiber Sheet Packings • Rag Felt Papers • Natural Cork

Any Speed They Want . . .

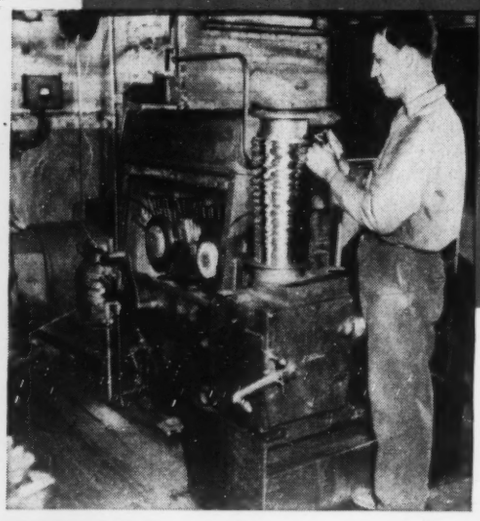
AT THEIR FINGER TIPS



66% Extra Gain in Output

To speed the cutting of a groove (.0065 inches wide, .0070 inches deep) on a cartridge wheel, a metals working plant installed this modern Sundstrand automatic lathe with special tooling, in place of an older type machine. Equipped with a two-speed, 2-to-1 ratio motor drive, the lathe turned out 3 pieces per hour.

By replacing the two-speed drive with electronic stepless speed control, the lathe's output was increased to 5 pieces per hour—an extra gain of 66 per cent, thanks entirely to Thy-mo-trol.



Better Quality of Wire, Less Breakage

With this one wire-drawing machine and Thy-mo-trol drive, Scovill Mfg. Co., can draw wire of several different sizes, because Thy-mo-trol's wide speed range provides the right speed for maximum production of every size wire. Thy-mo-trol not only provides a wide range of speeds, but it can hold each speed constant, regardless of load change. This has improved quality, particularly in the threading operation where the load varies greatly. And Thy-mo-trol's smooth acceleration minimizes wire breakage, and saves wear on the machine and dies.

See-Saws as She Breathes

Here's a unique application of Thy-mo-trol to a new-type oscillating bed for combating the crippling effects of polio. Built by Respir-Aid, Inc., the new bed is mounted on a motor-driven frame which the Thy-mo-trol drive see-saws in rhythm to the patient's breathing. By simply turning a small knob which electronically controls the speed of the driving motor, this attendant regulates the speed of see-saw motion.

These **3** Manufacturers Increased Output, Reduced Maintenance, and Improved Product Quality with

THY-MO-TROL

G.E.'s Electronic Adjustable Speed Drive

You, too,

can give your machines these advantages—

1. Wide Speed Range
2. Constant Speed, Regardless of Load
3. Stepless Speed Control

For more information about these inherent characteristics of Thy-mo-trol, and how it really works, ask your nearest G-E office for Bulletin GET-1223. *Apparatus Department, General Electric Co., Schenectady 5, N.Y.*

GENERAL ELECTRIC

676-247

With Civilian Plane-Builders
AND OWNERS, TOO

...AMERICAN PHILLIPS SCREWS "Win Wings"
through High Style — Peak Performance — *Stratospheric Production Savings!

In Production: American Phillips Screws give you "air age" fastening — fast, fumble-proof, slip-proof, reject-proof. Both the work and worker are out of harm's way — driving is automatically straight. When these engineered screws "button up" your products, *time-savings soar *as high as 50%* — volume booms and your net looks nicer!

In Promotion: The decorative, straight-set, unburred head of the American Phillips Screw can't catch clothes or hose — but it *does* catch the eye! Customers know, too, that they're buying top serviceability — they can see it! And long life — they expect it! Join the many makers of appliances, cars, radios and other products who are cashing in on the *double advantages* (Production and Promotion), provided by American Phillips Screws.

4-WINGED DRIVER CAN'T SLIP OUT OF PHILLIPS TAPERED RECESS

AMERICAN SCREW COMPANY, PROVIDENCE 1, RHODE ISLAND
Chicago 11: 589 E. Illinois St. Detroit 2: 502 Stephenson Building

AMERICAN PHILLIPS *Screws*

ALL TYPES
ALL METALS: Steel, Brass, Bronze, Stainless Steel, Aluminum, Monel, Everdur (silicon bronze)

KAISER ALUMINUM

HOW PERMANENTE METALS—IN A SINGLE YEAR—HAS BECOME A KEY FACTOR IN AMERICAN INDUSTRY—PRODUCING 175 MILLION POUNDS OF KAISER ALUMINUM!

One year ago, for the second time in over half a century, a new force stirred the aluminum industry.

After careful planning and organization, The Permanente Metals Corporation—led by Henry J. Kaiser and associates—started to carve out a permanent place in the aluminum world.

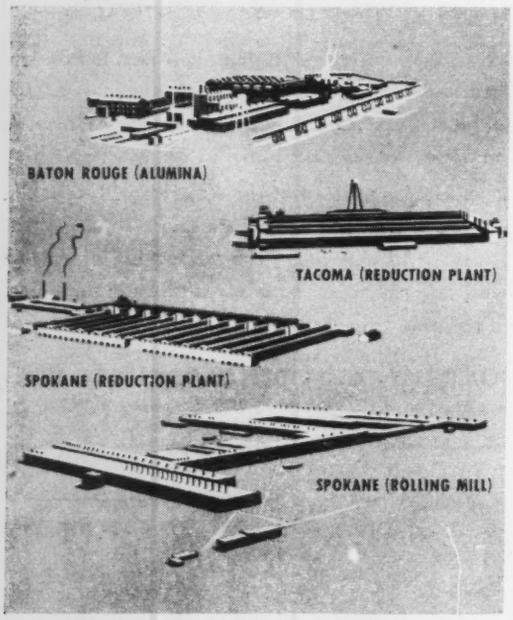
The first objective: To produce aluminum in tremendous volume and thus offset the shortage which was then crippling the production of finished products.

That this objective was achieved . . . and surpassed . . . is revealed by one statistic—175 million pounds of plate, sheet, and strip aluminum in the first year. Almost as much as the entire industry produced in the most productive year before the war!

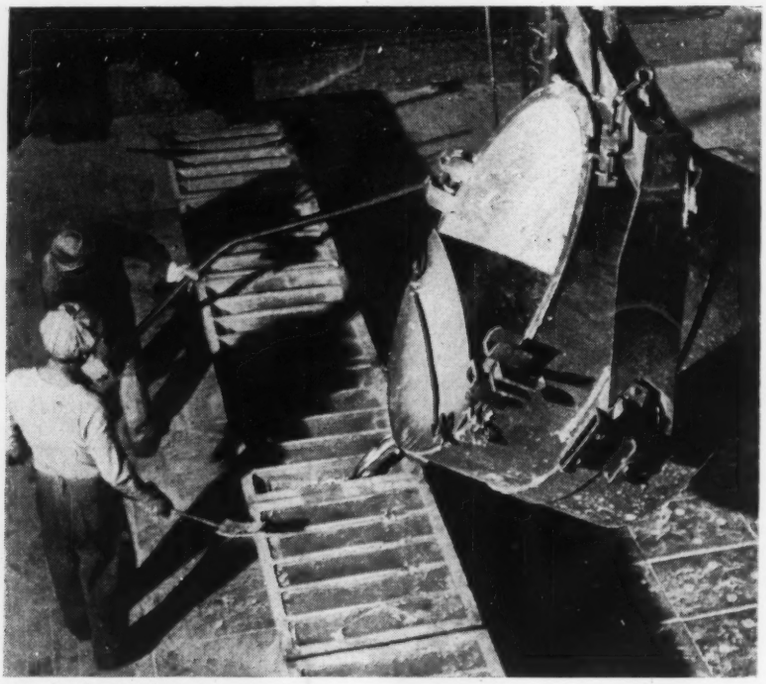
The pictures and text on these pages *partially* reveal how this was done.

What they cannot hope to portray is how administrative vision, technical skill, and a completely coordinated operation combined to make such production possible.

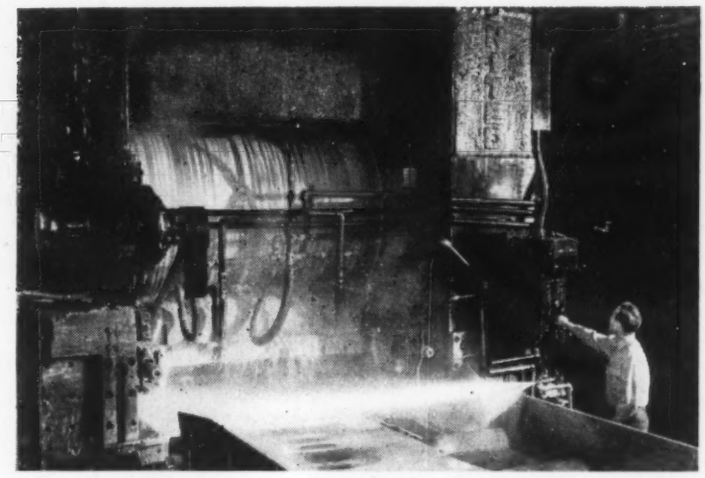
This same combination is now achieving Permanente Metals' second objective—to make Kaiser Aluminum, already second to none, the finest in the land!



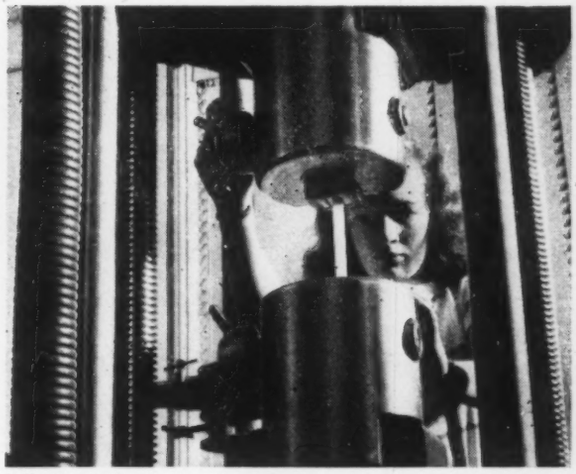
1. From bauxite processing to finished product—This chart gives a step-by-step picture of Permanente Metals' aluminum operation . . . which controls the production of quality aluminum from its huge bauxite processing plant at Baton Rouge, Louisiana . . . through its mammoth reduction and finishing plants at Spokane and Tacoma, Washington. Such integration assures fast, reliable service.



2. Preparing the "pig"—Operating eight modern pot lines, Permanente's reduction plants at Spokane and Tacoma, Washington, can turn out over 700,000 pounds of pure pig aluminum daily. This pig aluminum is then sent to the rolling mill, also in Spokane, where it is converted into alloyed ingots and then rolled into plate, sheet and strip.



3. Down the "hot line"—Permanente Metals' 53-acre Spokane rolling mill is one of the largest, most modern plants of its kind in the world. An example of its up-to-the-minute equipment is the "hot line," the giant rolls which convert alloyed aluminum ingots into sheet. This rolling mill is capable of producing 288 million pounds of Kaiser Aluminum a year.



4. Quality first—With production reaching new peaks, Permanente Metals is now concentrating on producing the highest quality aluminum ever offered to manufacturers. Constant chemical and physical tests plus infinite care in handling assure that customer requirements are not only met, but exceeded.

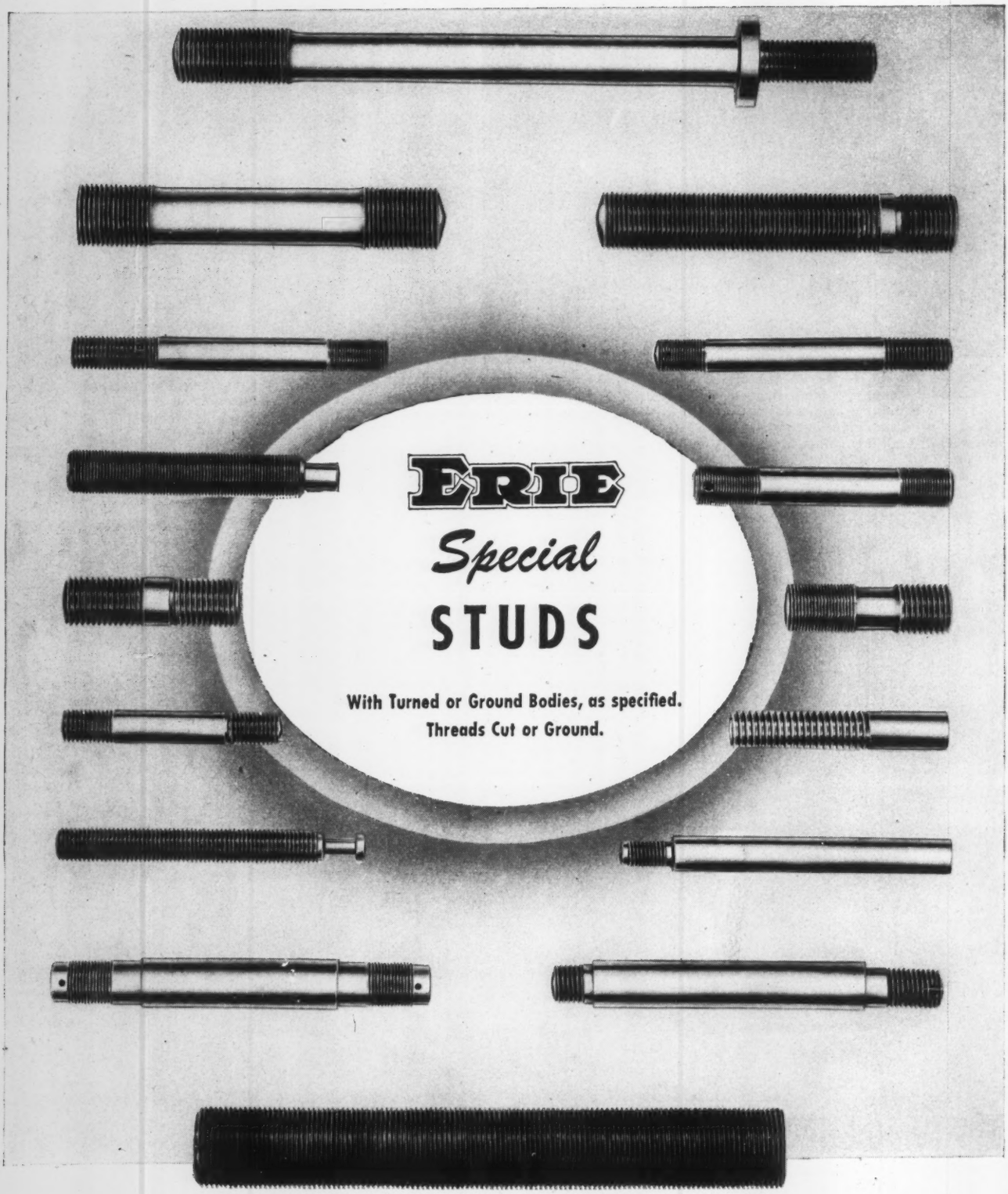
5. Ready to go—Here is the result of just one day's rolling mill production of Kaiser Aluminum. Ready to ship, it will go into aircraft, buses, building materials, house trailers, appliances, garage doors, kitchen utensils . . . will be welcomed by scores of America's leading manufacturers who rely on Permanente Metals for quality aluminum, fast, dependable deliveries, and an eagerness to be of service!

Ready to serve you—*today...*

Kaiser Aluminum

a Permanente Metals product

DISTRIBUTED BY PERMANENTE PRODUCTS COMPANY, KAISER BLDG., OAKLAND, CALIFORNIA . . . WITH OFFICES IN:
Seattle, Wash. · Oakland, Calif. · Los Angeles, Calif. · Dallas, Texas · Wichita, Kan. · Kansas City, Mo. · St. Louis, Mo. · Atlanta, Ga. · Minneapolis, Minn. · Milwaukee, Wis. Chicago, Ill. · Cincinnati, Ohio · Cleveland, Ohio · Detroit, Mich. · Boston, Mass. · Hartford, Conn. · Buffalo, N.Y. · New York City, N.Y. · Philadelphia, Pa. · Washington, D.C.



SEND YOUR BOLTING SPECIFICATIONS TO A SPECIALIST

A dependable source of high quality bolting for Railroads, Refineries, Diesels, Farm Machinery, Excavating Equipment and all types of Heavy Machinery.

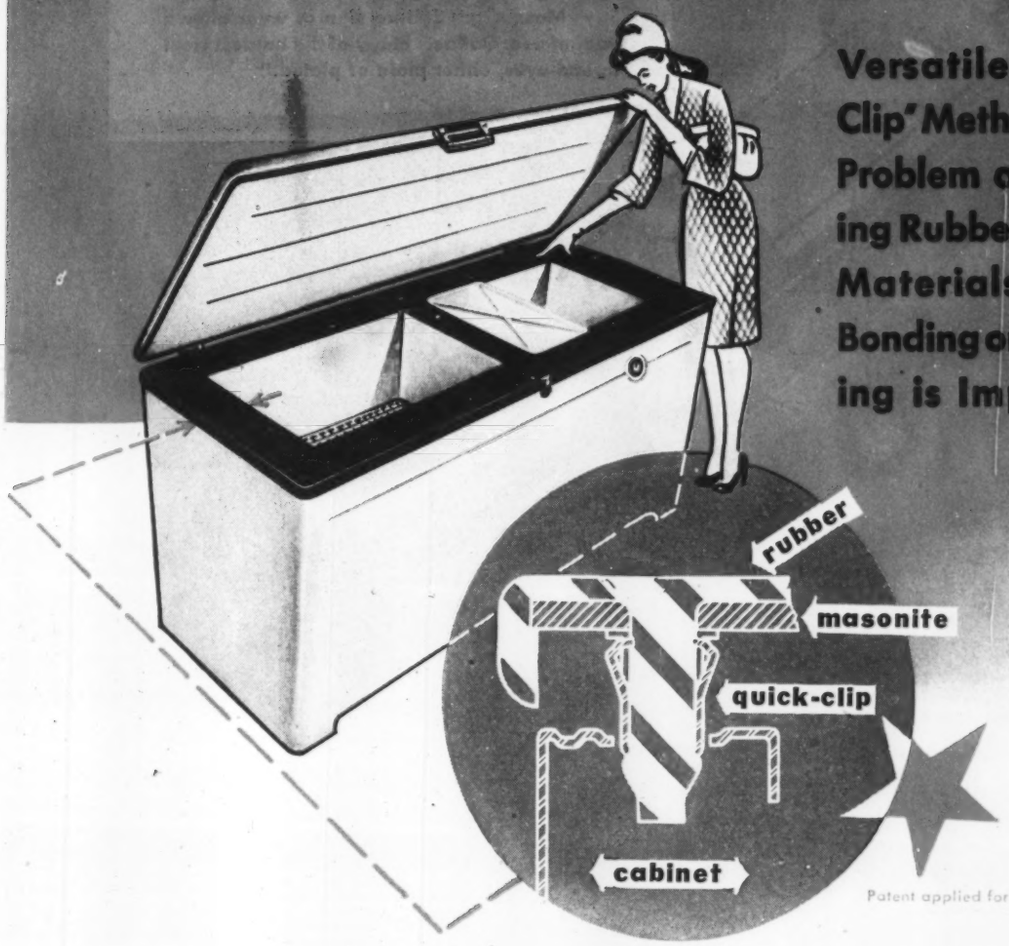
ERIE BOLT & NUT CO.

SUBSIDIARY OF BARIUM STEEL CORPORATION

ERIE, PA.

STUDS • BOLTS • NUTS ~ ~ ALLOYS • STAINLESS • CARBON • BRONZE

It's a "Snap" with "Quick-Clip"



Versatile "Quick-Clip" Method Solves Problem of Fastening Rubber to Other Materials Where Bonding or Cementing is Impractical

Although highly satisfactory in countless applications, the process of cementing or bonding rubber to metal or other materials is not always practical. One of many examples is the rubber breaker strip on low temperature "food freeze" cabinets.

ORCO engineers solved the problem by applying the new "QUICK-CLIP" method of fastening rubber to metal or other material. Rubber stems are molded integral with the rubber breaker strip and project downward on its under side. Specially designed metal clips—"QUICK-CLIPS"—are fitted to the rubber stems. Holes to receive these rubber-metal stems are located in the metal to be covered.

It's a fast, easy job for the assembler to place the breaker strip in position and snap the stems into the respective holes. This snap-in feature permits the entire fastening job to be handled from one side of the breaker strip. Attachment is positive and permanent, yet the replacement of the breaker strip after long usage is accomplished easily and without damage to the cabinet.

The Orco "QUICK-CLIP" method of fastening rubber to metal and other materials has wide application in diversified industries—automotive, refrigeration, ventilating equipment, office equipment, safety equipment, juvenile equipment, and in many types of equipment for the building industry.

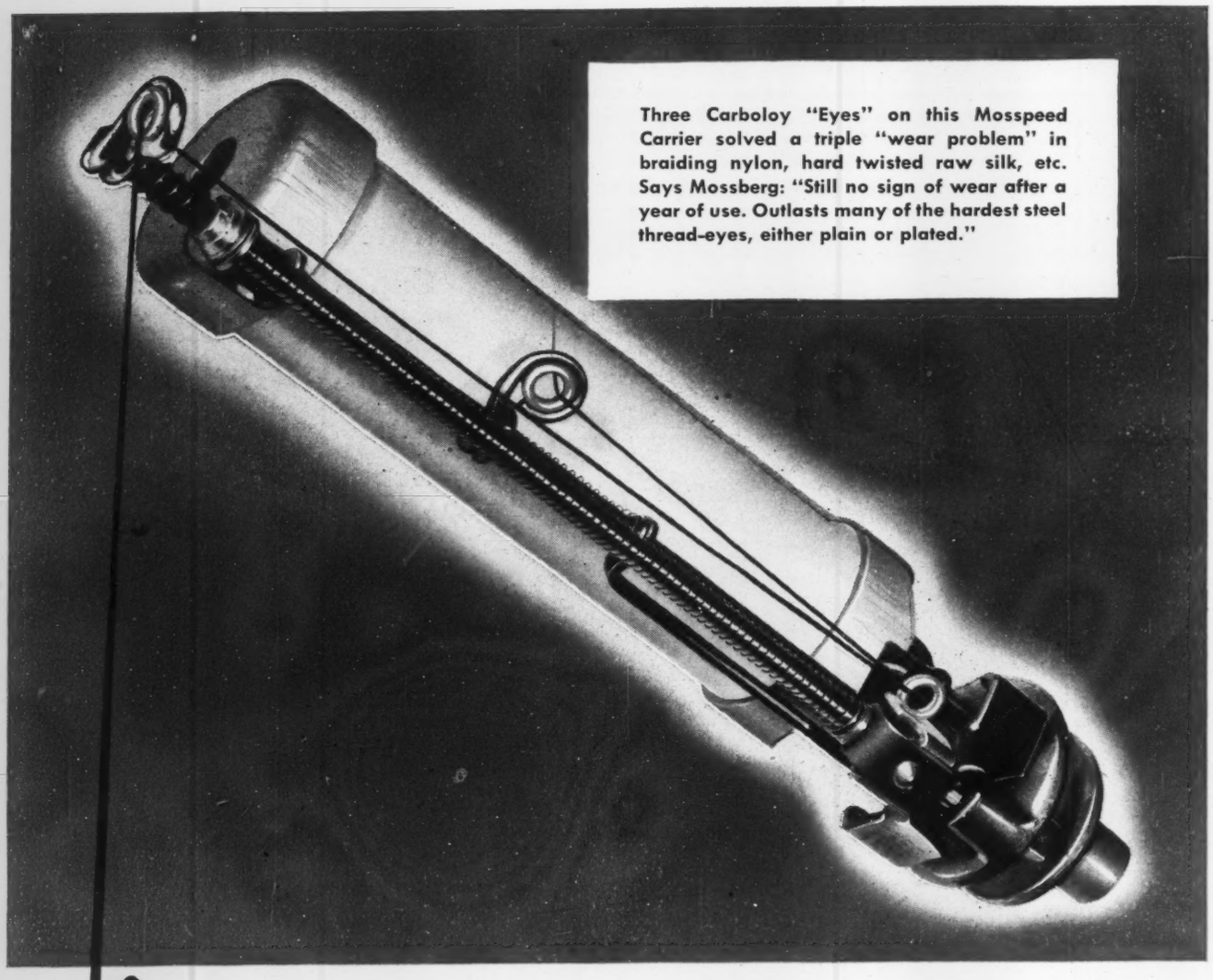
Pioneers in the development of rubber-to-metal adhesion and originators of the new "QUICK-CLIP" method, The Ohio Rubber Company is prepared to apply the most efficient method of fastening rubber to metal or other material. For complete details, communicate with:

OHIO RUBBER CO

FACTORIES:
WILLOUGHBY, OHIO • CONNEAUTVILLE, PENNA.
LONG BEACH, CALIFORNIA

BRANCH OFFICES:
NEW YORK • CHICAGO • DETROIT • BOSTON
CLEVELAND • INDIANAPOLIS

THE OHIO RUBBER COMPANY · WILLOUGHBY, OHIO



Three Carboloy "Eyes" on this Mosspeed Carrier solved a triple "wear problem" in braiding nylon, hard twisted raw silk, etc. Says Mossberg: "Still no sign of wear after a year of use. Outlasts many of the hardest steel thread-eyes, either plain or plated."

You can "PULL THE WOOL" over These Eyes ... and They like It!

Threads—such as nylon or silk—may *seem* soft but they actually wear through even hard steel or porcelain rapidly! Ask the textile manufacturer! Fast wear on eyes or guides through which threads pass causes frequent downtime of machines and costly loss of production.

To stop that loss, manufacturers tried Carboloy Cemented Carbide Guides—and found they kept machines running as much as 100 times longer.

Thousands of Wear Resistant Uses!

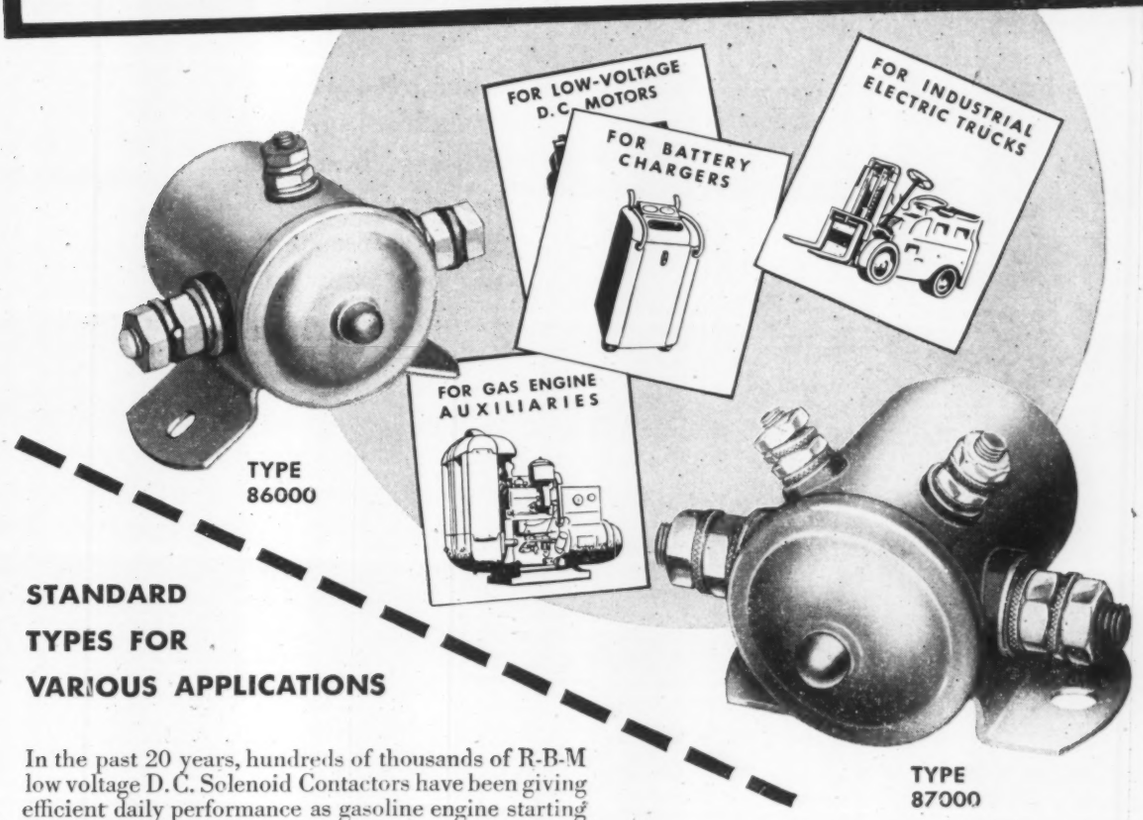
This is but one of the thousands of wear resistant uses in which Carboloy hard metal today is helping make equipment last far longer and operate far better than ever before possible. A wide range of products—from fish rods to window screens—have benefited. Perhaps Carboloy can solve your wear problem too! Carboloy Company, Inc., 11113 E. 8 Mile Road, Detroit, Mich.

CARBOLOY

Hard Metal

TO REDUCE WEAR ON MACHINES AND PRODUCT PARTS

TIME-TESTED • PERFORMANCE-PROVED
SOLENOID CONTACTORS



STANDARD TYPES FOR VARIOUS APPLICATIONS

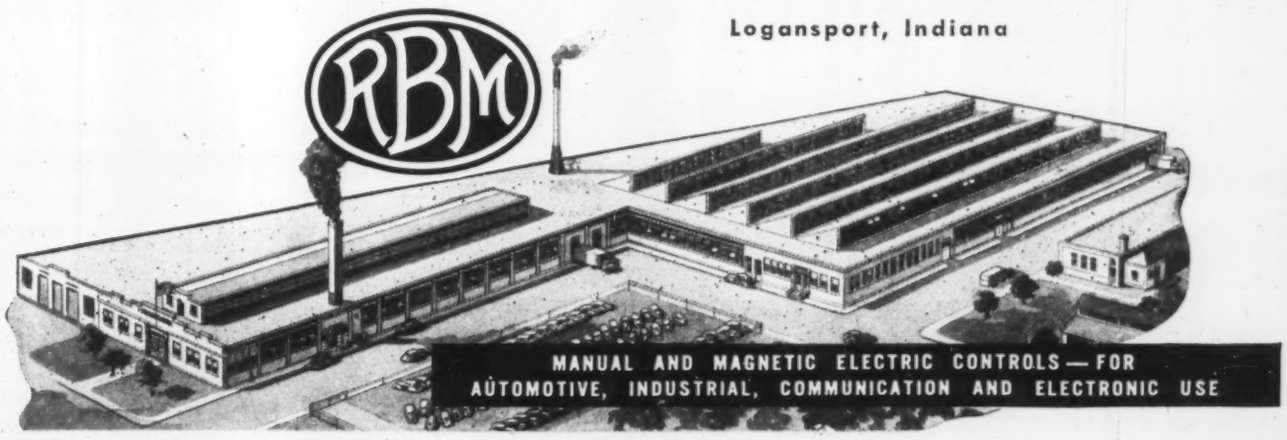
In the past 20 years, hundreds of thousands of R-B-M low voltage D.C. Solenoid Contactors have been giving efficient daily performance as gasoline engine starting contactors—battery charging contactors—low voltage D.C. motor controls—auxiliary contactors for industrial electrical trucks—and on mobile and stationary gasoline engine driven apparatus of all kinds.

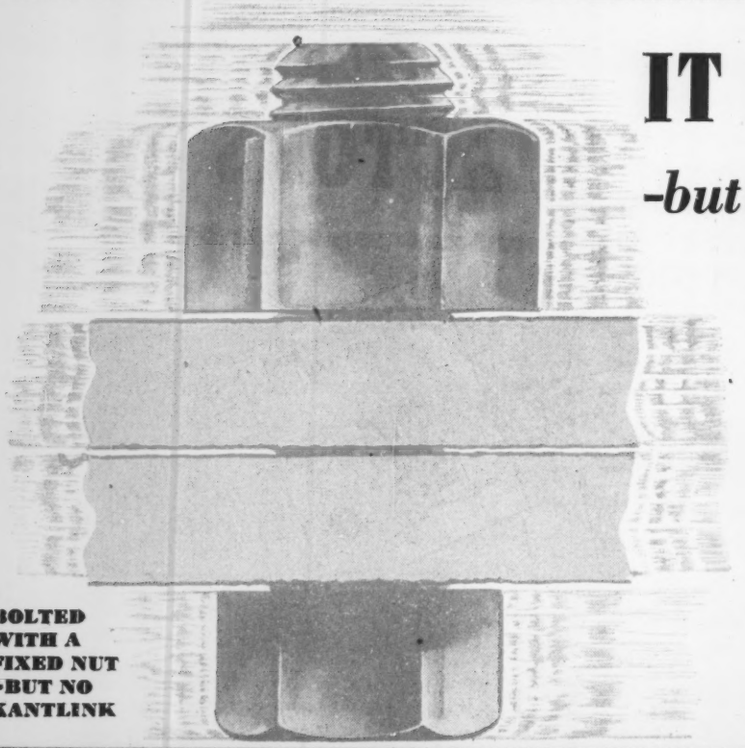
R-B-M Solenoid Contactors can be furnished with insulated coil terminals or with one insulated coil terminal; the other coil lead may be grounded or connected to the line terminal. All types can be supplied with either flat or curved mounting bracket.

Contacts are single pole, normally open, double break rated at 100 amperes continuous inductive load; or 300 amperes in-rush at 6 volts D.C. and at 50 amperes continuous inductive load or in-rush at 32 volts D.C. Copper contacts are standard, though special alloys are available. Coils are available from 6 to 32 volts D.C. continuous or intermittent duty.

For further information, write for Bulletin 520. Address Dept. H-7.

R-B-M DIVISION
ESSEX WIRE CORPORATION
Logansport, Indiana





BOLTED WITH A FIXED NUT —BUT NO KANTLINK

IT LOOSENED!!!

-but the nut never budged!

Of course it loosened. All bolted assemblies inevitably loosen because of bolt stretch, and frictional wear of metal on metal, burrs, flares or the pulverizing of rust, paint and scale—*when you do not use a spring washer.*

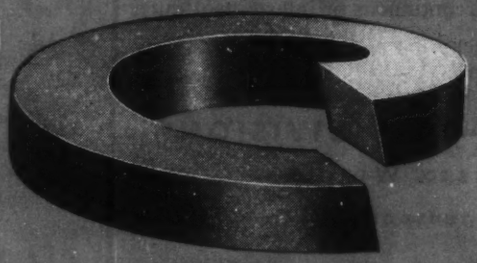
NOW Let's see what happens when you do use spring washers

The nut—fixed or standard type—may never budge a hair's breadth—in fact a nut *can't* budge while there's the slightest pressure on its threads and the threads of the bolt. *But* the other parts of assemblies *always wear loose, except when* a strong spring washer is used to expand as initial wear occurs. The *spring* expands with wear, and holds *all parts tight longer.*

A spring washer is a *must* for *real bolted security.*

There is no substitute. Specify Kantlinks.

Send today for descriptive folders.



Originators of

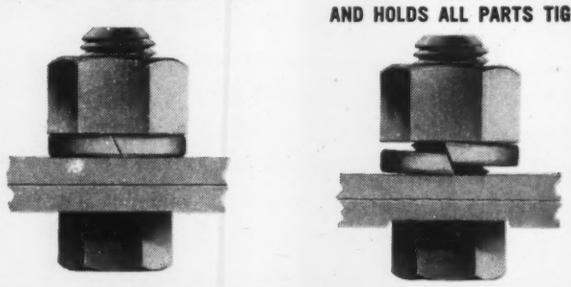
KANTLINK

the long-range spring washer

This happens when you use KANTLINKS

BEFORE WEAR
IT'S TIGHT—WRENCHED TIGHT

AFTER WEAR—STILL TIGHT
—THE SPRING EXPANDS
AND HOLDS ALL PARTS TIGHT



WITH ANY NUT USE KANTLINKS

THE NATIONAL LOCK WASHER COMPANY

Newark 5, New Jersey — Milwaukee 2, Wisconsin

How to be sure of continued precision for the life of your machine

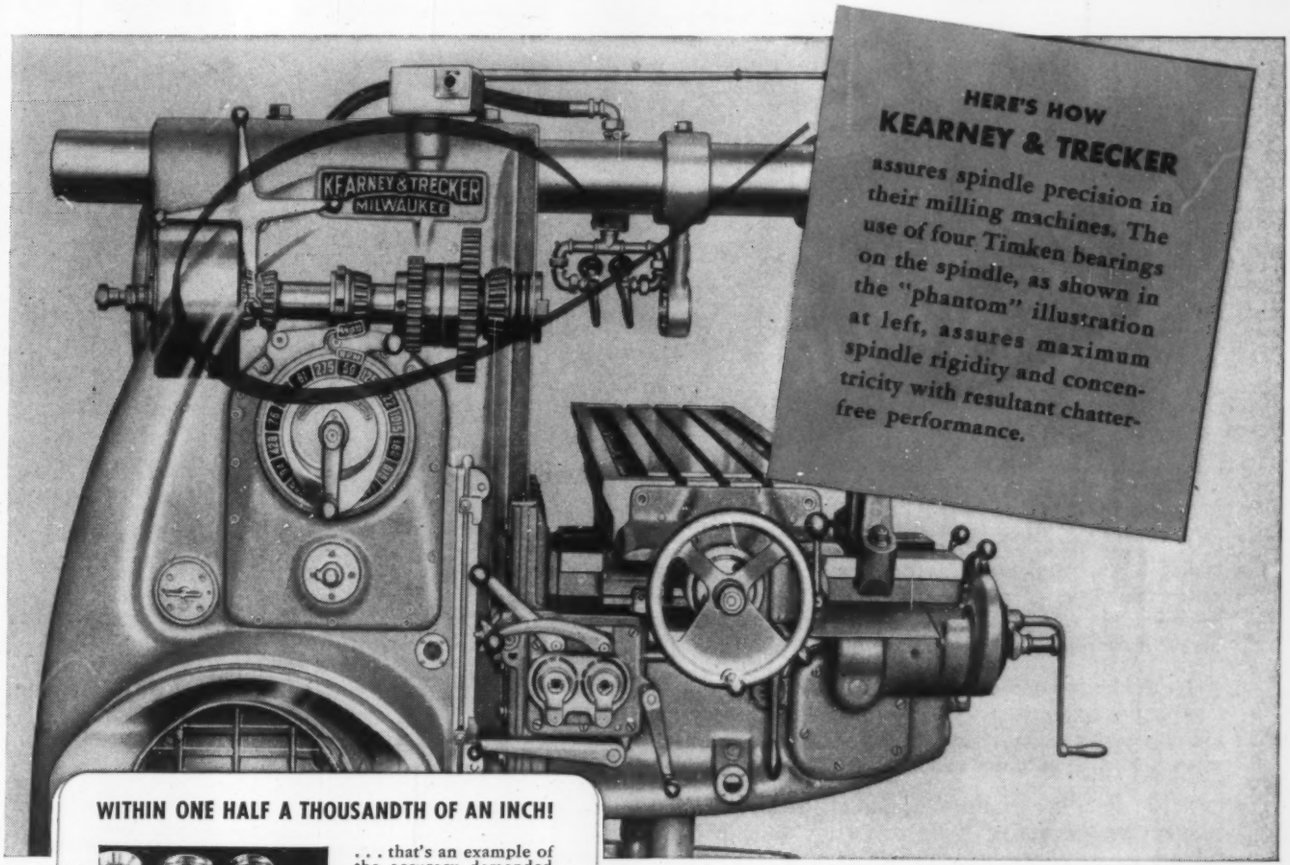
TIMKEN tapered roller bearings on the spindles of your machine tools give you precision right from the start—and hold it throughout the life of the machines.

Accurate preloading to any desired degree is possible due to the basic Timken bearing provision for "take up". Maximum support is provided by the line contact between tapered rolls and races. The bearings themselves are precision products, made to exactingly close tolerances. They *retain* this precision indefinitely due to scientifically-correct design; "Generated Unit Assembly" (eliminating need for re-adjustment); and the finest material ever developed for tapered roller bearings—Timken alloy steel. Result: chatter-free performance, maximum rigidity and long-life precision under all speeds, feeds and cutting loads.

Remember, no other bearing can bring you *all* the advantages you get with Timken bearings—backed as they are, by 49 years of bearing research and development. That's why it's so important to make sure you have Timken bearings in every machine tool you manufacture or buy. The Timken Roller Bearing Company, Canton 6, Ohio.

TIMKEN BEARING EQUIPPED

This symbol on a product means its bearings are the best.



HERE'S HOW KEARNEY & TRECKER

assures spindle precision in their milling machines. The use of four Timken bearings on the spindle, as shown in the "phantom" illustration at left, assures maximum spindle rigidity and concentricity with resultant chatter-free performance.

WITHIN ONE HALF A THOUSANDTH OF AN INCH!

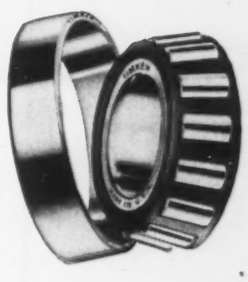
. . . that's an example of the accuracy demanded in the outside diameter of Timken bearing cups in order to pass inspection . . . just one instance of the rigid quality control under which Timken bearings are produced.

Timken is the only bearing manufacturer which makes its own steel, and is the acknowledged leader in: 1. advanced design; 2. precision manufacture; 3. rigid quality control; 4. special analysis steels.

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS



NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▱ BEARING TAKES RADIAL ◫ AND THRUST →◫← LOADS OR ANY COMBINATION →◫←

Reg. U. S. Pat. Off.

Knurling of Socket Screws originated with "Unbrako" in 1934.

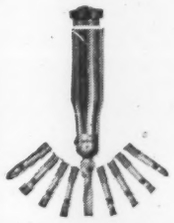
(A) The knurled head of the "Unbrako" Socket Head Cap Screw makes it slip- and fumble-proof—be the fingers and heads ever so oily—therefore, it can be screwed-in faster and farther before it becomes necessary to use a wrench. The "Unbrako" Socket Cap Screw may also be a self-locker . . ask us how!

(B) The knurled cup point of the "Unbrako" Socket Set Screw makes it a Self-Locker—the point digs-in and stays dug—regardless of the most chattering vibration. Yet, it can be backed-out with a wrench and used over and over again.

(C) The knurling of this "Unbrako" Socket Set Screw, as shown, swages the threads so it becomes a most excellent Self-Locker—for use where the points such as: flat, dog, cone and oval do not lend themselves to knurling.

Millions of these "Unbrako" Socket Screw Products—in sizes from No. 4 to 1-1/2" in diameter and in a full range of lengths are being used throughout industry to save assembly time, facilitate compact designs, reduce weight and costs. Write for the "Unbrako" Catalog—very interesting and informative.

"Unbrako" and "Hallowell" Products are sold entirely through Industrial Distributors.



KITS: Pat's Pend.

You can't screw socket screws in or out without a hex socket wrench, so why not get our No. 25 or No. 50 "Hallowell" Hollow Handle Key Kit which contains most all hex bits.

OVER 44 YEARS IN BUSINESS

STANDARD PRESSED STEEL CO.

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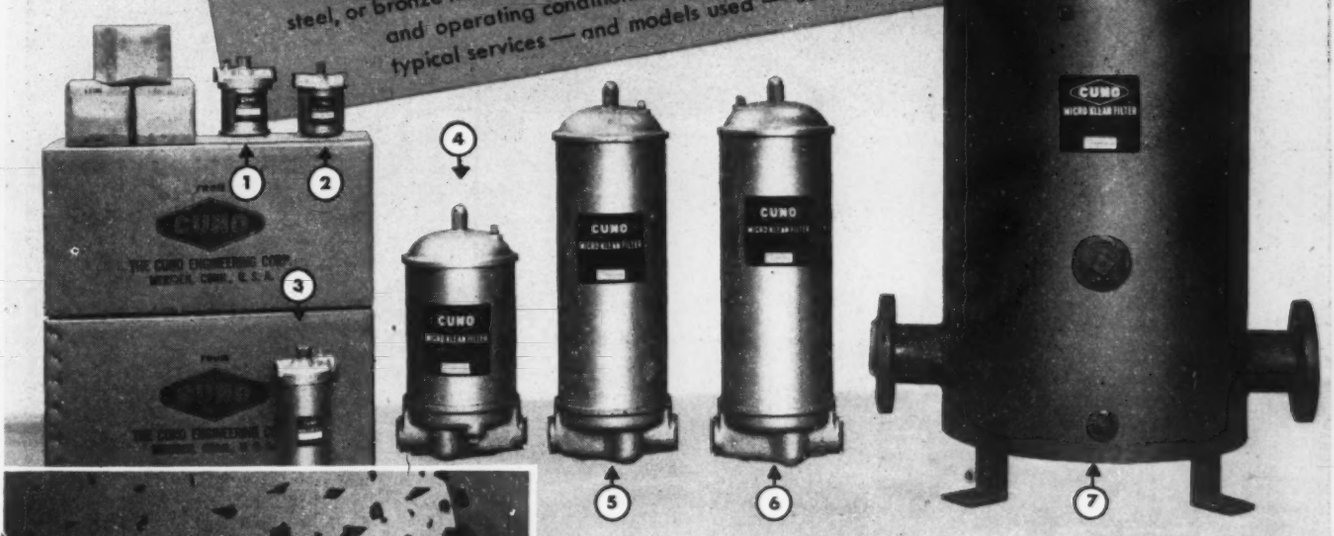
YOU COLLECT DOUBLE

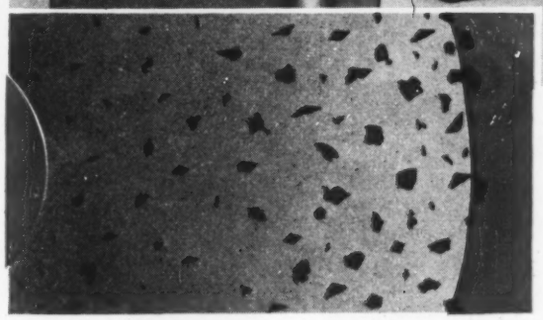
with MICRO-KLEAN Fluid Cleaning

Here's the micronic filter with the exclusive cartridge construction that saves 50% in cartridge replacement costs... because it collects double the quantity of solids before clogging.

A FILTER SIZE FOR EVERY JOB!

Connections from ⅜" IPS to 6" flanges—capacities from a few gallons per hour to 850 GPM or more — single or multiple cartridge units. Your smallest or your largest filtration problem can now be handled with a single compact unit sized to the job requirements! Constructions in die-cast aluminum, cast iron, welded steel, stainless steel, or bronze make these filters adaptable to a wide range of fluids and operating conditions. For specific examples of typical services — and models used — see below.





1. Graded Density in Depth — a newly developed method of "felting" creates a structure in which spaces between fibres become progressively smaller and more numerous approaching discharge surface. Smaller particles penetrate to varying depths — no surface sealing.

2. Controlled Fibre Distribution — gives consistent, uniform, filtration characteristics.

3. Resinous-Impregnated and Polymerized — each fibre bonded in position to give structural strength. No channeling, rupturing, shrinking or distortion.

4. 85 to 90% Porosity — no structural components to waste space. RESULT: higher flow rates, greater dirt capacity, longer cartridge life.

Cuno Micro-Klean cartridges fit other makes of filters — increase efficiency.

1. Model 1B1-2230: Adopted by leading machine tool manufacturer as standard equipment on grinding machine lube oil system. 250 # operating pressure.

2. Model 1C1-2230: Widely used on domestic oil burners.

3. Model 1B1G-2239: Air line filter as used by automobile manufacturer on plant air service.

4. Model 3A1-2278: For chemical manufacturer to filter light mineral oil solution of DDT.

5. Model 3A2-2278: All bronze model purchased by chemical manufacturer for process water in manufacture of stearates.

6. Model 3A2-2278: For manufacturer of electric motors to filter lubricating oil on test stands.

7. Model 30D2-2278: For manufacturer of transformers to handle petroleum solvent used in final cleanup and hydrostatic test of transformer housings.

Other Filters May *Appear* to Be Built This Way . . . But Only the Cuno MICRO-KLEAN Has All 4 Reasons for Double Life

For new bulletin on MICRO-KLEAN Filters, or to have Cuno representative discuss with you some specific fluid-cleaning problems, write (on your business letterhead) to Cuno Engineering Corporation, 202 South Vine St., Meriden, Connecticut.

CUNO

Fluid Conditioning

Removes More Sizes of Solids from More Types of Fluids

AUTO-KLEAN
General service down to .0035". Disc-type. Continuously cleanable.

FLO-KLEAN
For highly abrasive solids down to .0025". Wire-Wound. Continuously cleanable.

MICRO-KLEAN
Micronic-type. Molded Fibre. "Graded Density in Depth" cuts replacement costs.

COOLANT-KLEAN
Low-cost unit filtration of grinder coolant. Fabric-type element.

Steel-Weld FABRICATION

In the production of various frames, bases, housings, etc., such as the unit illustrated above, where quantity production is not anticipated, welded steel is the solution . . . it saves time, reduces cost, and gives you greater strength with less weight. The Steel-Weld Division of The R. C. Mahon Company stands ready to meet your requirements regardless of size, weight, shape or construction . . . thoroughly experienced Mahon design engineers and highly skilled workmen are your assurance of a better job, and a finer appearing job embodying all of the inherent advantages of Steel-Weld Fabrication.

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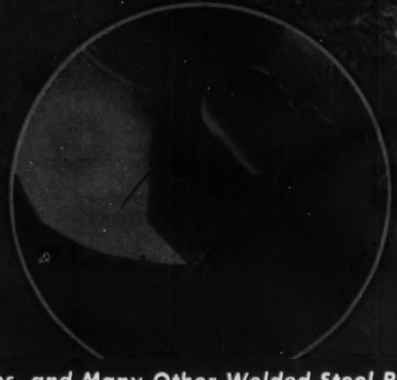
Detroit 11, Michigan



Engineers and Fabricators of Welded Steel Machine Bases and Frames, and Many Other Welded Steel Products

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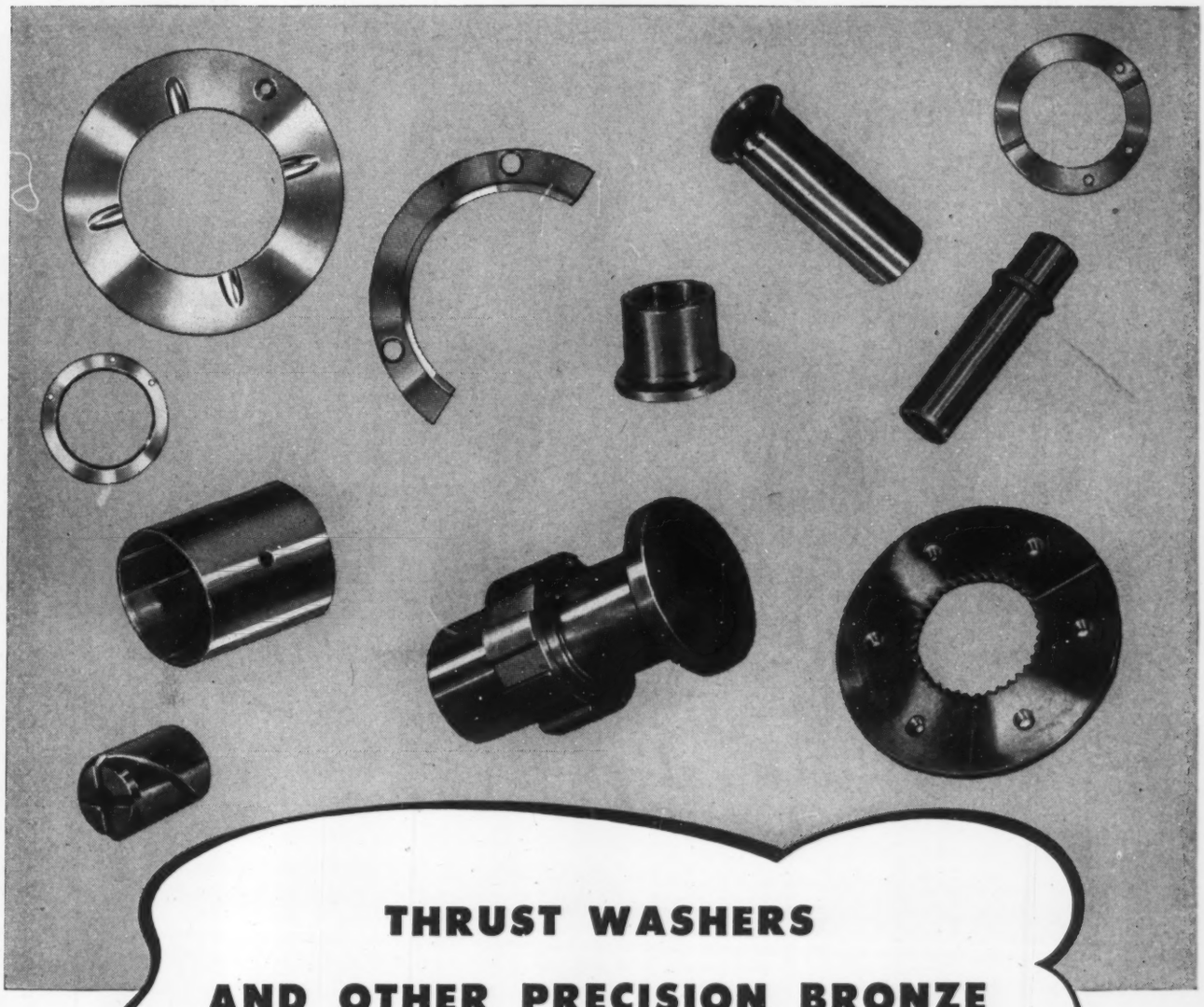

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AND OTHER PRECISION BRONZE
PARTS FOR IMMEDIATE DELIVERY

Our rigid standards for materials and manufacture can produce thrust washers of superior performance at low cost for you. We are equipped to manufacture a wide variety of sizes and shapes of thrust washers and other precision bronze parts and hold them rigidly to your specifications. Extensive research and engineering facilities are at your service. Your inquiry is invited.

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Power goes to work through

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Silent FEDERAL Mogul **SLEEVE BEARINGS**

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know Roller Chain...

PUTS POSITIVE PERFORMANCE IN YOUR DESIGN!

• BALDWIN-REX ROLLER CHAIN DRIVES put plus value in your machines . . . add to product salability! For example, their positive action eliminates slippage and conserves power costs. They transmit more horsepower in less space, assuring compactness. Through the use of roller chains, you get the advantage of maximum flexibility in your drive design arrangements plus the inherent elasticity that protects machines against shocks and momentary overloads. And properly applied, they usually last the lifetime of the machine.

We're not talking through our hats on that long-life statement. In our product development laboratories, we actually prove the wear-resistant abilities of Baldwin-Rex. On machines such as this, the chain is run at excessively high speeds over small sprockets under conditions considerably more severe than actually encountered to determine life expectancy. In this manner, we obtain data on choice of materials, degree of heat-treatment, and design of parts that enable us to give you the best in roller chain . . . and assure you the most economical drive for your machines.

When specifying roller chains for your machines, remember that you can simplify chain selection, generally cut costs, and improve deliveries by specifying standard roller chains. Your Baldwin-Rex man will be glad to give you all the facts and assist you with your application problems. Call him or write direct to Baldwin-Duckworth Division of Chain Belt Company.

BALDWIN·REX

ROLLER CHAINS

BALDWIN-DUCKWORTH DIVISION OF CHAIN BELT COMPANY

320 Plainfield Street, Springfield 2, Massachusetts

An Airtight Story

HOW does Brandt of Baltimore figure in the story of an airtight bottle cap?

Take for example the Crown Cork and Seal Company. It makes an airtight bottle and can cap. A tough little cork disc is used. The disc is sliced from moulded sticks of granulated cork held together by a special glue mix. This binder is specially prepared in Semi-Circular Mixing Kettles made by Brandt. A large all welded stainless steel tank handles 2000 gallons of mix at one time, utilizing electric heating racks and a stainless steel helix paddle.

Take any industry requiring specialized metal equipment in the handling or manufacture of its product and you'll likely find Brandt *somewhere* in the story. Large or small, if your metal working problem is special, call Brandt.

STAMPINGS FORMING
HEAVY WELDMENTS

Spot welded assemblies, plate fabrication, complete assemblies, crating and shipping facilities.

Mild steel, stainless steel, armor plate, sheet metal, aluminum, magnesium, non-ferrous metals.

A highly specified Naval Gun Housing for "Operation Mothballs." Just as a bottle cap must be airtight so must the protective housings on the U. S. Navy's Mothball Fleet. Here is another specialized product from Brandt's broad and diversified metal working facilities.

ALL UNDER ONE ROOF
In the midst of major rail, water and highway transportation facilities.

BRANDT
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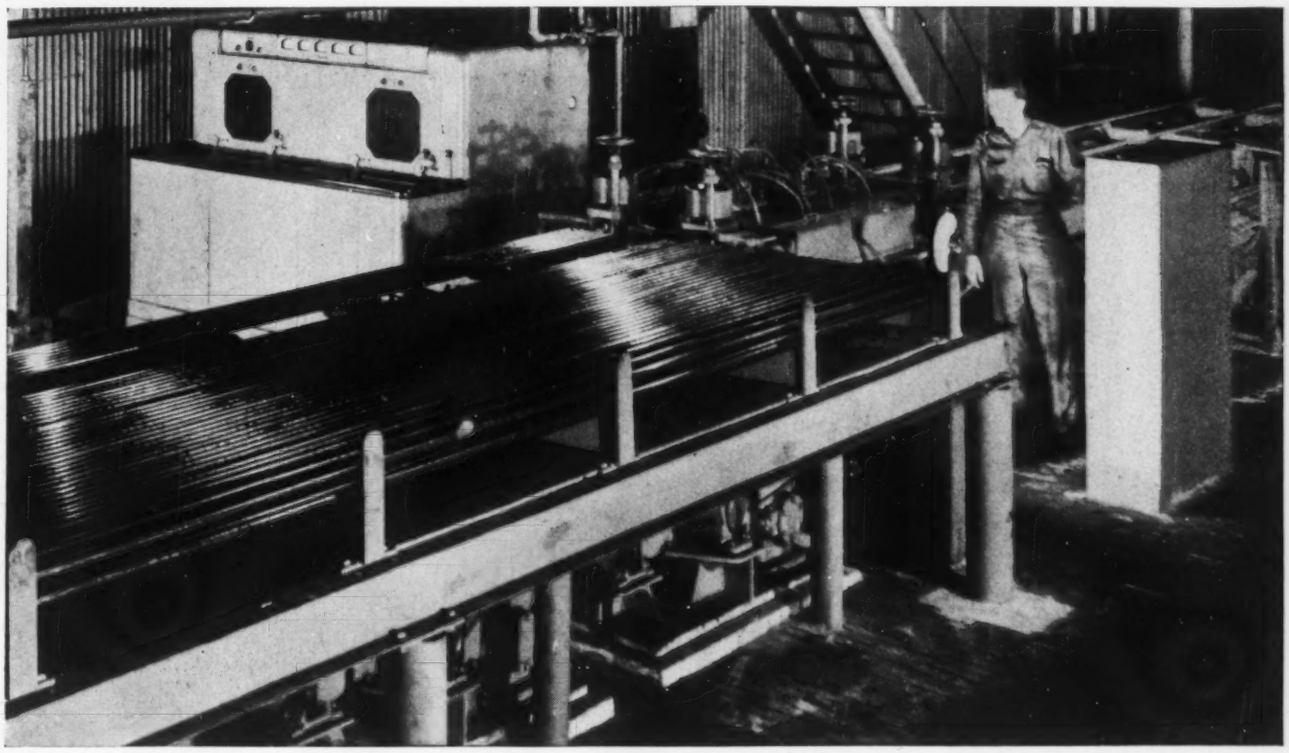
CHARLES T. BRANDT, INC., 1700 RIDGELY ST., BALTIMORE-30, MD.

57 Years of *Specialized* Metal Working Experience



J&L steps up *Quality* of bars with TOCCO Induction Hardening

• Jones & Laughlin Steel Corporation, the first steel company to use induction hardening for treatment of steel bars, reports that it is passing on to its customers these benefits in improved quality:

1. INCREASES UNIFORMITY of metallurgical structure as to *hardness* and *depth of hardness*—throughout its entire length and cross-section.

2. IMPROVES MACHINING. Elimination of hard and soft spots promotes consistent uniformity of machining.

3. IMPROVES SURFACE. Speedy, localized hardening practically eliminates scale and distortion for greater product quality.

4. MINIMIZES METAL LOSS. Less skin removal through decarburization.

J & L is now TOCCO hardening cold-finished round bars in lengths of 10 ft. to 24 ft., in diameters of ½″, ¾″, ⅞″, 1″, 1⅛″, 1 3/16″ and 1 7/16″; will process 2″ bars soon; and expects also to treat flat and hex stock.

The completely automatic work handling equipment with TOCCO Induction Heating unit is shown above. Controls are readily adjusted to suit the size of bars to be treated and the degree and depth of hardness desired.

TOCCO Engineers will gladly explain the TOCCO process and study its application to your particular problems.

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Send bulletin giving further details on the J & L bar stock application.

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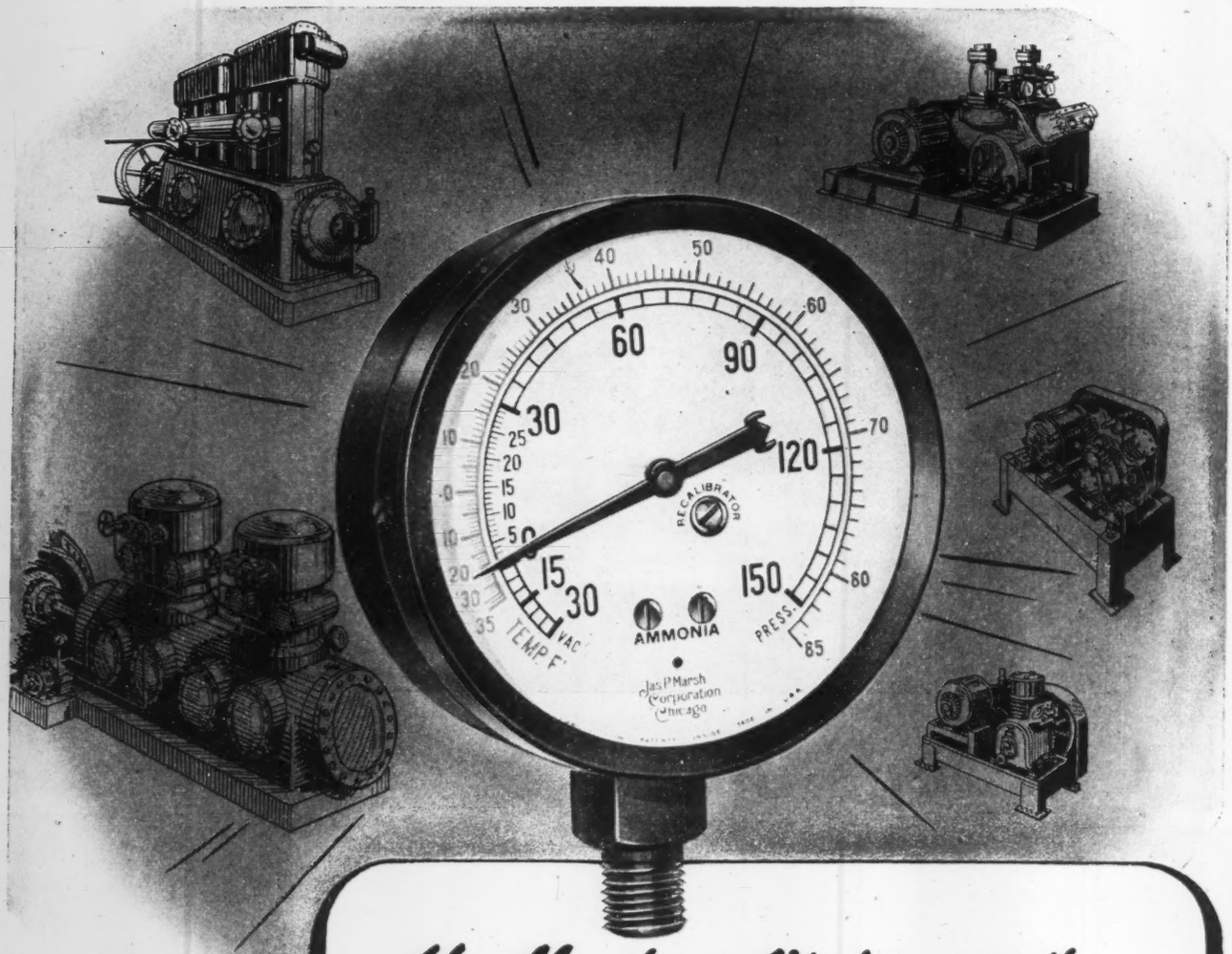


Yes, Marsh quality has won the **REFRIGERATION** *field, too—*

If you know Marsh quality, it won't surprise you to find that Marsh Pressure Gauges are preeminent in the refrigeration industry. The current census clearly shows that more manufacturers of refrigeration compressors equip their units with Marsh Gauges than any other make. And numbered among these users are the big names in this exacting industry where precision and stamina are a mandate.

You could ask for no higher testimonial to Marsh quality than this, yet Marsh Gauges have written a similar story into the records of every industry where pressure gauges are used. In the applications where the going is toughest — where the needs are most critical — Marsh is the gauge chosen by the most discriminative manufacturers to become a vital part of their equipment.*

Keep this in mind when you select pressure gauges—or equipment requiring gauges. Insist on the instrument that has proved first choice of industry for the most critical services.

Jas. P. Marsh products include: A full line and range of gauges in pressure, compound, altitude, hydraulic, sprinkler, ammonia, ounce-graduated retard, test, and diaphragm types. Dial thermometers in rigid stem and remote reading types. *Ask for literature.*

JAS. P. MARSH CORP. 2039 **Southport Avenue, Chicago 14, Illinois**
Export Dept.: 155 E. 44th St., New York 17, N. Y.

MARSH GAUGES

"THE STANDARD OF ACCURACY"

MARSH ALONE HAS THE "RECALIBRATOR"

. . . quickest and best way to correct a gauge that has been knocked out of adjustment by improper handling.

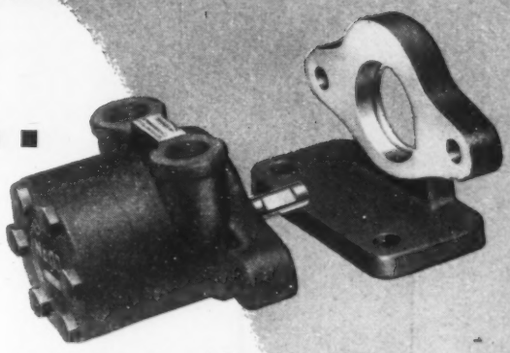
*One of a series of advertisements citing examples of this.

PUMPS that Match YOUR standards..

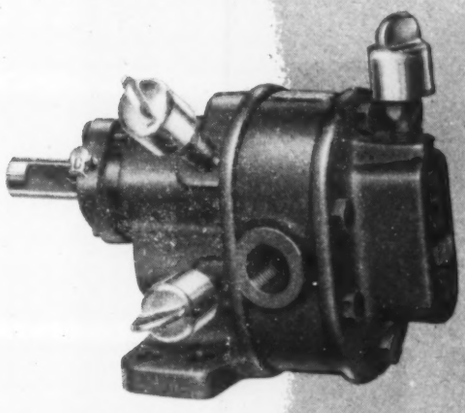
WHENEVER you are designing or redesigning equipment that requires pumps for cooling, lubricating or hydraulic systems, insure your standards of quality and performance with Brown & Sharpe precision-built pumps. You can count on them for efficient, trouble-free, long-life performance . . . the result of practical designing, sound construction, and many years of experience in building and operating pump-equipped machines.

Brown & Sharpe Pumps are made of selected materials. Their parts are generously proportioned and those subject to wear are designed to give long, continuous service.

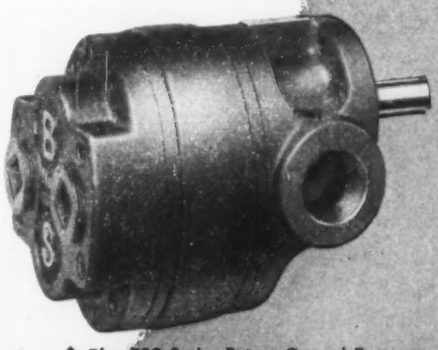
Get acquainted with the specific facts and performance figures of the complete line of Brown & Sharpe Pumps . . . Rotary Geared, Vane, Centrifugal and Motor Driven. If you have a pump problem that requires a special design, Brown & Sharpe may have a solution. Write for catalog. Brown & Sharpe Mfg. Co., Providence 1, R. I., U.S.A.



No. 00 Rotary Geared Pump . . . supplies oil for lubrication or for coolant where small capacities are desired.

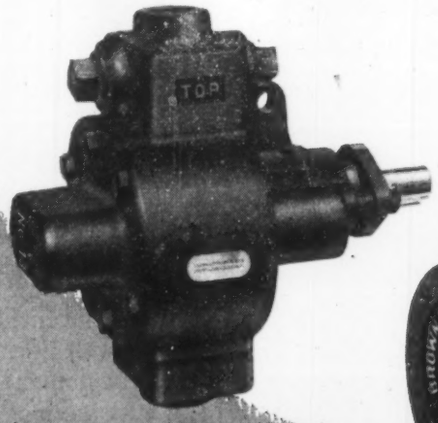


No. 21 & 23 Bronze Rotary Geared Pumps. Designed for use where a corrosion-resisting pump is required.

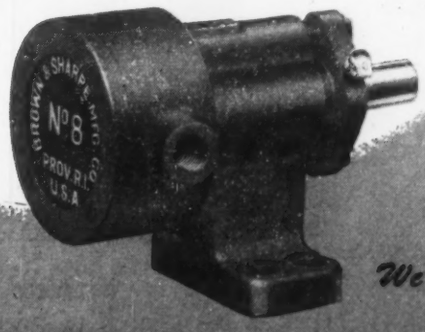


***The* 500 Series Rotary Geared Pumps** for hydraulic installations are designed to be driven direct, run quietly at high speeds for pressures up to 500 psi.

No. 8 Reversible Type Vane Pump, used to circulate coolant to cutting tools of light metal working machines or as a lubricating pump. Maintains same direction of flow when shaft rotation is reversed.



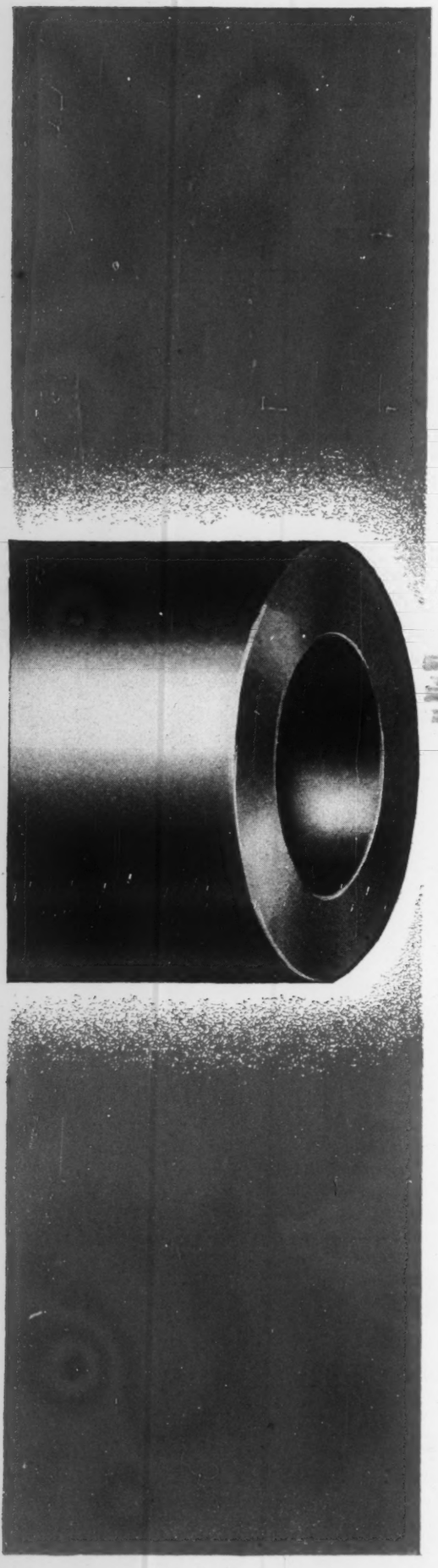
Nos. 11, 12 and 13 Rotary Geared Pumps, Reversible Type. Maintain same direction of delivery when rotation is reversed. Specially adapted to machines which operate in both directions.



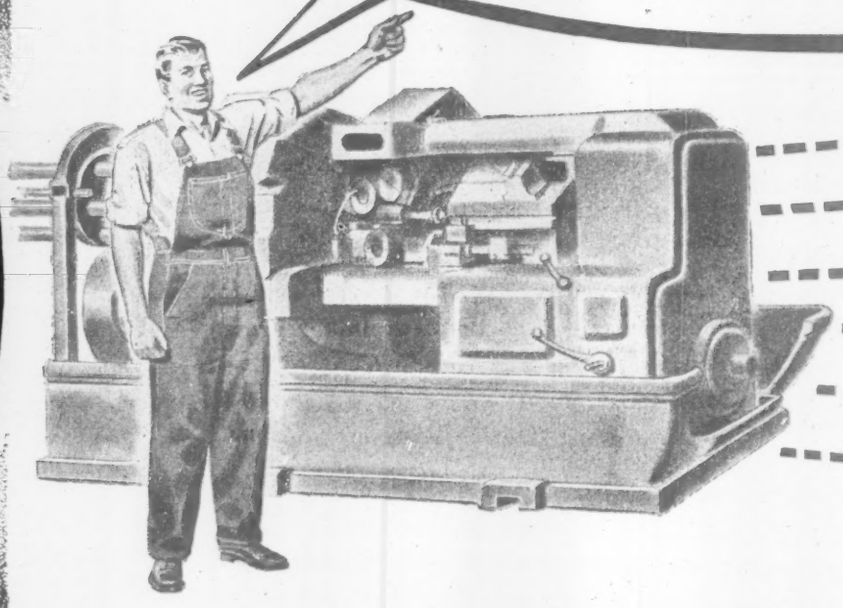
B·S

We urge buying through the Distributor

BROWN & SHARPE PUMPS



THEY COME O
60% TO 100% F
Rockrite T

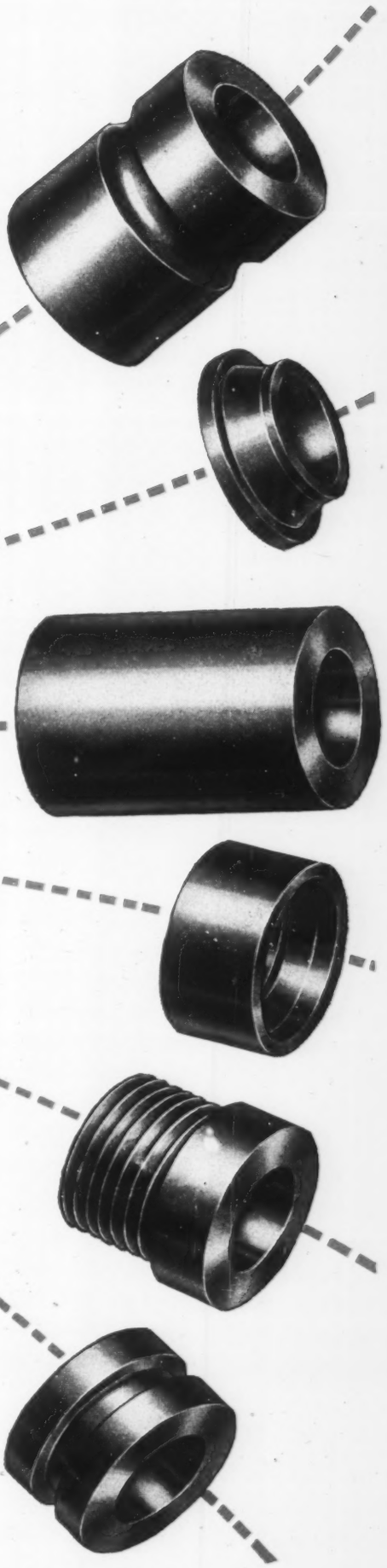


New, even startling, possibilities in screw-machine output of cylindrical and ring-shaped parts have been opened up through the use of Rockrite Tubing. In one case, two parts were finished simultaneously from Rockrite Tubing whereas only one could be made at a time from ordinary mechanical tubing. The output of parts per machine hour in other cases has been raised 60 per cent . . . even 100 per cent.

Rockrite Close Tolerance Tubing is more concentric than commercial tubing, has less variation in wall thickness, and is sized to closer outside- and inside-diameter tolerances. Lighter, faster, more uniform cuts are made possible, permitting practical use of forming tools with longer tool life, and other advantages.

In many instances slow boring can be eliminated as a bottle-neck to production. Fewer machining operations are required, and frequently stations can be released for added operations.

E OUT
% FASTER FROM
E TUBING



Rockrite Tubing is available in a variety of metals, and also as bi-metal tubing, long-piece tubing, and tapered tubes.

Production shop executives will find in Rockrite's 20-page booklet many valuable, tested ideas which can apply specifically in their own plants. Write today for your copy. Ask for booklet, "Rockrite Close Tolerance Tubing." There is no obligation.

TUBE REDUCING CORPORATION

WALLINGTON
NEW JERSEY

Topics

CHARTS recently published by the Engineering Experiment Station of the University of Illinois provide a simple graphical procedure for computing vertical displacements at the surface or within the interior of an elastic, homogeneous, isotropic solid body bounded by a plane horizontal surface and loaded by distributed vertical loads.

NUMERICAL INDEX for filing data sheets and related information has been developed by the American Society of Tool Engineers to speed the systematic location of specific data and to simplify the comparison of vendor specifications and design. The index is divided into three sections: Crude materials, basic materials and products, and end products.

THIN SHEET-IRON covers to protect electrodes from oxidation losses, caused by gases and flame while smelting ferroalloys, have been utilized by the Japanese to effect appreciable savings in electrode life.

PICTURES PROJECTED on a screen within 30 seconds after exposure are automatically developed in a General Electric camera used for rapid testing. The camera itself is capable of exposures as small as one-millionth second. When a photograph is taken the operator pushes a button, setting into action automatic developing equipment built into the camera.

SELF-CLEANING sludge tanks developed by Hapman Conveyors Inc. utilize pipe conveyors to carry away the settlings from the bottom of the tank. Synthetic rubber flights, mounted on sealed-pin chains, are sprocket driven through pipe, following bends and removing the sediment for deposit in a container.

TRIVISION LENS for three-dimensional photography has been developed by Bausch & Lomb Optical Co. Coated with light-transmission film to minimize reflection the lens is supplemented by a standard film, embossed with minute ridges or lenticulations on the side opposite the emulsion. Resulting photographs give an astonishing sense of depth without resorting to use of stereoscopic spectacles. Actually it is possible "to see around and beyond" images in the picture as the observer changes his angle of view.

DEEP-HARDENING STEELS which can be machined and processed easily into shafts, gears and pinions subject to heavy duty service have been developed to reduce material and manufacturing costs. Known as U.S.S. SuperKore the steels show hardenability equal to or greater than more highly alloyed grades now in common use.

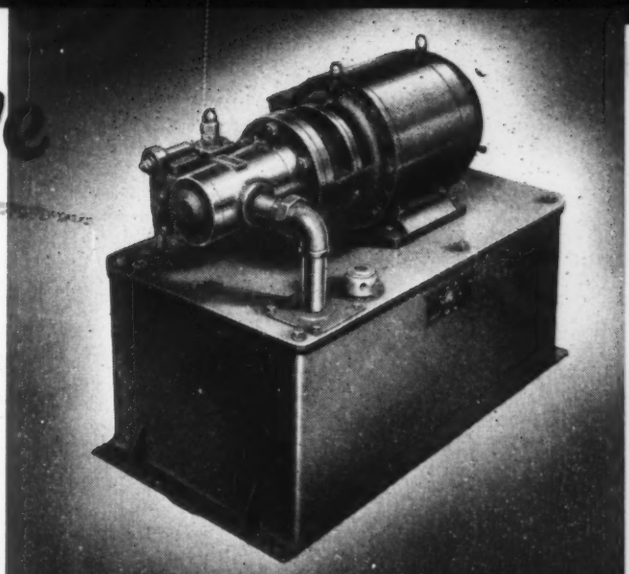
IN A RECENT DEMONSTRATION RCA Victor showed that improvements in radio reproduction have reached such fidelity as to be virtually undistinguishable from "live" music.

SUPERSONIC TESTING method developed in Germany can locate bubbles in sheet metal which are too minute for detection by X-ray or magnetic techniques, according to a report of the Office of Technical Services, Department of Commerce. A bubble of 0.00001-millimeter in diameter can cause a hundredfold drop in energy of supersonic vibrations through the material.

ELECTRONIC-TWIST setting for tire cord and other textile products has been patented by Industrial Rayon Corp. Packages of the cord are passed through a high-frequency electrical field, resulting in such uniform reaction that 18 pounds of rayon cord may be treated at one time in a matter of minutes.

SUPERCHARGERS, successfully applied to large aircraft engines, are needed for smaller engines used on personal or feeder-line types of planes. Continuing trend for altitude compensation and increasing number of planes making altitude lanes over airports necessary will require development of superchargers for engines under 1000 horsepower, according to W. O. Meckley, General Electric Co.

Simplify and Save on Hydraulic Systems with VICKERS POWER UNITS



The "hydraulics" on this Ingersoll 24-Station Process Machine transfers the transmission castings from station to station and provides power for clamping, locating and chip disposal. The hydraulic system design was simplified and cost reduced by using the twelve standard Vickers Self-Contained Hydraulic Power Units shown.

These units provide a compact hydraulic power package which can be applied to almost any system. They are available with various pump combinations to meet a wide range of requirements up to pressure demands of 2,000 psi. There are 92 standard sizes and types of single stage, two stage and dual pressure pumps equipped with motors from ¾ to 20 hp.

The oil reservoir serves as a base to save floor space. On it is mounted a standard Vickers Motorpump or a Vickers pump with separate motor drive. A Vickers "balanced piston type" pressure relief valve provides accurate control of hydraulic pressure. A simple wrench adjustment sets maximum operating pressure at any desired figure within recommended pressure range. Filters and reservoir are readily accessible for cleaning. See Bulletin 46-43 for the many other features.

Vickers Hydraulic Power Units are frequently the most desirable source of hydraulic power. Vickers application engineers will be glad to discuss your hydraulic power and control problems.

3158

Birdseye view of Ingersoll 24-Station Process Machine (130 feet long) that performs 170 different drilling, tapping and milling operations, producing automobile transmission housings at the rate of 100 per hour.

Write for new Bulletin 46-43 describing Vickers Hydraulic Power Units

VICKERS Incorporated

DIVISION OF THE SPERRY CORPORATION

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Vickers Engineering Offices: ATLANTA • CHICAGO • CINCINNATI • CLEVELAND
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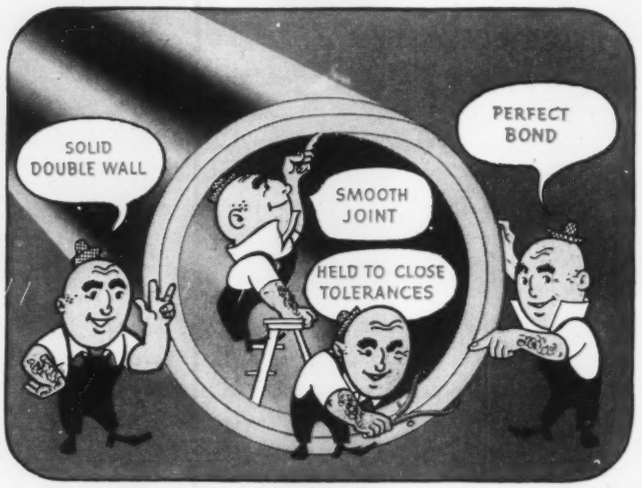
ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

Your stomach can't tell winter from summer

1. **GARDEN-FRESH** peas and corn are tempting lures for many people, while others prefer juicy garden beets or tasty lima beans. Whatever the choice, they agree on this—the fresher, the better! Housewives today can answer this call, even in winter. But they need help to do it.

2. **SILENT PARTNER** in preserving summer freshness all year around is the modern freezer unit. At home or in the store, these units keep food so super-fresh, you can't tell by tasting whether it's winter or summer. But freezing units themselves need help to do this job well.

3. **BUNDYWELD** tubing in condenser and evaporator coils, compressor lines and connecting tubes helps bring dependability in freezer units. Bundyweld's many other uses include carrying fuel, oil, lubricants, vacuums and hydraulic fluids in motor vehicles and gas in modern ranges.



4. **BUNDYWELD** is different from other tubing. A single strip of basic metal, coated with a bonding metal, is rolled continuously twice laterally into tubular form, then metallurgically bonded by intense heat—carefully controlled—to form a solid, double wall tube, held to close dimensions.

5. **TAKE** the recommendation of many engineers and product designers who recognize the advantages of this unique, superior tubing. *Specify Bundyweld.* Let Bundy Research and Engineering Departments show the advantages of Bundy Tubing for your product. Available in steel, Monel and nickel. *Bundy Tubing Company, Detroit 14, Michigan.*

BUNDY TUBING

★ ★ ENGINEERED TO YOUR EXPECTATIONS ★ ★

BUNDY TUBING DISTRIBUTORS AND REPRESENTATIVES:

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MACHINE DESIGN

Stepping stones to DESIGN

By B. P. Graves
Director of Design
Brown & Sharpe Mfg. Co.
Providence, R. I.

THE OPPORTUNITY to tell what should be done with engineering education is an assignment which a mature machine designer hesitates to accept. Perhaps I can take a cue from an inquiry we received recently. It was a routine request for a 180-inch straight edge except that it contained the startling clause "guaranteed not to sag"—no suggestion as to how a straight edge can be prevented from deflecting, no comforting admission that 0.0005-in. or less would be considered as good as no deflection, not even a comment on the possibility of ever attaining the goal, just the blunt specification "guaranteed not to sag".

WHAT DOES INDUSTRY EXPECT the young designer to know when he leaves college? A well-considered answer, offered by Mr. Graves in a recent talk before the American Society for Engineering Education, is presented in this article. The author's views deserve the careful attention not only of young designers but also of design executives

This inquiry has suggested that I might describe the end result we would like to see in a young engineer after graduation. How to get him to this state, what to teach him, and how to teach it, are the problems of his professors. Like the nonsagging straight edge, it may even be that the end is impossible of attainment but, unlike the inquiry, we are willing to allow a liberal tolerance and won't insist on a guarantee of perfection.

Since my views on engineering have been developed from a lifelong association with the machine tool industry, it might be well to refer briefly to this industry to give a little background. Although it is the backbone of this mechanical age, the industry is a small one. Its plants are not set up with endless assembly lines and it produces in lots of one to fifty rather than in millions. Its engineers must be versatile—prepared to work on all the problems presented by a machine, and on the partially related problems of such different machine

tools as grinding, milling, and automatic screw machines. Single machines or small lots of machines cannot carry the costs of exhaustive studies, and a machine tool designer is limited in the time he can devote to his particular assignment. He must have a good knowledge of fundamentals and must use this knowledge in making many decisions where exact information is lacking. For example, a designer must recognize the points where stress concentration will exist, must know the design steps to reduce its effects, and yet may never know just what the stresses are in the case involved, inasmuch as the cost of lucite models and strain-gage investigations can rarely be carried by a single machine tool order, although we are doing much along these lines on our standard machines.

With this background, our first demand is for young engineers with a thorough training in the fundamentals of engineering—men who know their mathematics, physics, mechanics, strength of materials, and the theory of structures so well that they have confidence in their

"points where stress concentration will exist"

knowledge and, when faced with a new problem, will fall back on this basic knowledge and begin their analysis from there. In our industry there are hundreds of problems and fields of design which are not covered in college courses. No engineering school has courses in milling cutter design and few students have heard about clearance, rake and spiral angles. We do not think college courses should be given in milling cutter design, but how can the young engineer who must take up this work be prepared? The surest way of helping him is to ground him in fundamentals. He should be so sure of his mechanics and force analysis that he won't get lost in the complex forces which act on cutter teeth. He should be well grounded in the basic concepts of heat, the conversion of work to heat, and the flow of heat through a mass and from one medium to another. We can give him details and help him on from here, but with such a basic training he can go forward himself.

As we began a new program of applying electrical controls to machine tools we were faced with many problems in design which no college courses had ever considered, and the answers to which in many cases weren't known. The engineers assigned to the job were qualified only if they knew the fundamentals of engineering and were prepared to proceed from there. A typical problem which bridged the fields of mechanical and electrical engineering was the design of a high-speed viscosity switch. In the operation of a milling machine some actions must be controlled by the direction of motor rotation. For example, when a milling cut is completed, it is desired to reverse the direction of table motion and to return to the loading position at quick-traverse speed. If the cut is a blind one, or one approaching a shoulder, it is imperative that the reversal precede the shift to quick traverse. If this sequence is upset the table jumping forward at quick traverse rate will jam the work into the cutter and cause a smash-up. To be certain the desired sequence of actions is never violated, a viscosity switch can be used and through it the direction of motor rotation can open and close control circuits. This was a simple solution except for the fact that there weren't any successful, high-speed viscosity switches. A few bulky, low-speed devices were on the market but nothing of small size that could be operated directly on a 3600-rpm motor shaft. No courses, electrical or mechanical, cover the design of viscosity switches; no textbook discusses the principles of design, or ventures empirical rules. Faced with design problems of this type, an engineer must depend on his knowledge of engineering fundamentals. Backed up with the ability to calculate the viscous drag of an oil film and a knowledge of the generation and dissipation of heat and its influence on viscosity, an ingenious designer can work out an acceptable design. With a sketchy knowledge of fundamentals, he will have a discouraging record of tries and misses.

Hundreds of similar design problems can be found in our industry, including small tool design, gear pump design, hydraulic motors, grinding machine spindles, high-speed chain drives, etc. These subjects are not taught in school—it would be an impossibility to try to cover them. The only help that can be given a young engineer who must work in these fields is to ground him in fundamentals, repeating, emphasizing and hammering away at them.

You know, I know, all good mechanics know, even

"a discouraging record of tries and misses"

some students know, that you can't slide a thin washer along a shaft by pushing at one point on its outer edge; the washer is self-locking. The fundamental analysis is simple and many engineers can probably draw the free body diagram. However, I can show you at least four variations of this problem where engineers have fallen into the self-locking or near self-locking trap: A V-plunger pushed by slow-moving table dogs; single-shoe shifting forks moving splined clutches; short lands on

intermittent gears; and small pinions journaled in large bearings. Give the problem some new clothes and the young engineer hasn't a firm enough grasp of the fundamentals of friction analysis to see trouble spots. We have spent hundreds of design hours and thousands of dollars planning and making corrections just because designers did not or could not draw free body diagrams and unknowingly let friction forces get out of line with applied forces.

I always hesitate a little when I get on the subject of friction for it suggests a groups of our designers who were standing around a new machine looking at a mechanism which wouldn't work correctly. One designer was explaining that there was too great a difference between the static and kinetic friction coefficients and for that reason operation was erratic. An old-time mechanic who had assembled the machine rather bluntly interposed with "I don't think that's it". The designer, irritated, said "Why George, I'll bet you don't know what static friction is". "Oh yes I do—that's what wears the seats out of the pants of the Engineering Department".

It is obvious enough to designers that parts must be so proportioned that they will not be overstressed by working loads. Designers are far less aware of the necessity of proportioning parts to control deflections which occur under these loads. In the machine tool industry more design decisions are based on rigidity than on strength. Because of this, I believe more attention should be paid to deflection analysis in machine design courses.

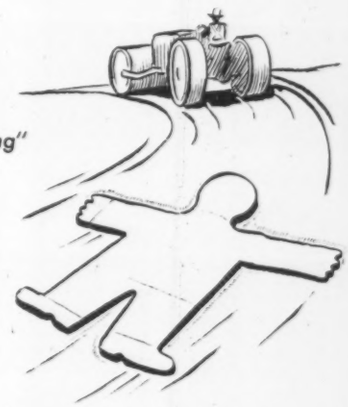
Modern machine tables or slides cannot be positioned with accuracies of 0.0001-inch unless table screws, screw thrust bearings, and supporting brackets are designed to deflect less than 0.0001-inch. Machines cannot produce surfaces of fine finish with micro-inch readings below 10 unless wheel spindles and work-supporting members have good rigidity and can keep their relative positions within this 0.00001-in. figure. Machines cannot produce work flat and square within fractions of thousandths unless machine ways can hold alignment under shifting loads.

"there is something nice and positive about breakage"

An engineer working on fine measurements or a designer working on small tools almost forgets the problem of strength and is instead forever concerned with the problem of rigidity. No one worries about whether a micrometer will break, whether a dial indicator post will snap, or whether a surface plate will be overloaded, but if any one of these deflects 0.0001-inch it may be a failure worse than breakage. After all, there is something nice and positive about breakage, but a little error from deflection can quietly slip into your measurements and give you nervous exhaustion trying to reconcile repeated readings.

There is one specific deflection problem which I find generally ignored. That is the problem of the relative deflection of a journal and its bearings. Even engineers will make lengthy calculations of load-carrying capacity, heating, location of oil inlets, etc., and never suspect that deflection may make these calculations useless. We appreciate the problem when we consider the design of plain-bearing grinding machine spindles. These bearings, lubricated with water-thin oil (32SSU), and operating with a radial oil space of 0.0001 to 0.0002-inch are highly sensitive to deflection. The overhanging loads produced by the grinding wheel on one end of the spindle and the V-belt drive at the other end can easily give a spindle enough slope to make it touch, metal to metal, on opposite ends of a bearing. Reliance on the proportions usually shown for bearings, or trust in the empirical rule that length should be two or three times the diameter, is likely to lead to trouble.

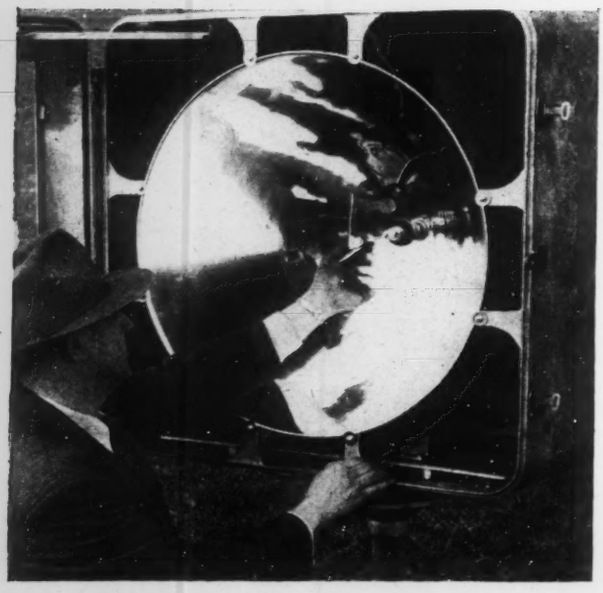
"thorough grounding"



It is suggested that instructors and junior professors be encouraged to spend some part of their summer in industry, and that this engineering work be given the same status as research or writing. The difference between book problems and practical problems has been likened to that between changing an automobile tire in the garage and changing a tire on a narrow, highly-crowned, soft-shouldered road on a rainy night. If teachers are to prepare men for industry, they must know what is required and the best way to obtain this information is by practical experience. The experience would be vivid and their teaching would be more interesting because of the experience.

In conclusion, I need only point out that if a boy is taught the design of punch presses, we shall probably put him to work on sewing machines. If he is prepared in internal combustion engines, we shall most likely ask him to lay out a centrifugal pump; and if he is taught all about electric generators, there is a good chance he will spend his days trying to determine which millionth of an inch a strain gage is indicating. Thorough grounding in the fundamentals and a unified knowledge of engineering will help him more than all the specialized knowledge in the world.

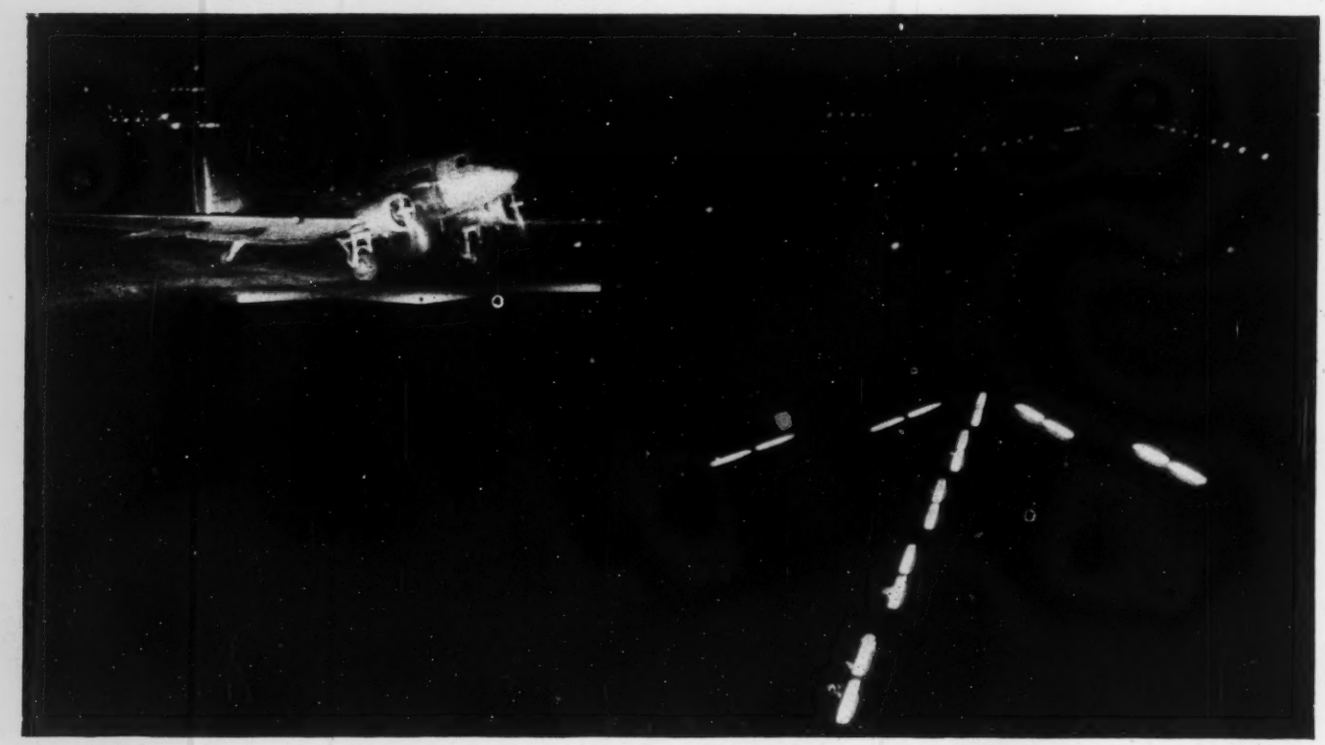
Scanning THE FIELD for Ideas



Lighting system, below, designed to penetrate 1000 feet of the thickest fog is expected to reduce sharply the number of airplane crashes caused by poor visibility. Placed in front of the airport runway, lights appear as a green arrow as shown. If, however, the runway is obstructed the lights are changed by the control officer to a flashing red cross.

Supplementing radio and radar, the system developed by Westinghouse Electric Corp. also utilizes kripton-filled flash-tube units, extending 2/3-mile ahead of the green arrow runway designator. Each unit has a brilliancy of 3,300,000,000 beam candlepower. One of these lamps is shown at left. An idea of its power can be obtained from its energy consumption which is at the rate of over 3,000,000 watts during the peak flash period. Units are flashed successively, one after another to give the effect of a streak of lightning traveling toward the runway.

The kripton units also operate on a "low" intensity



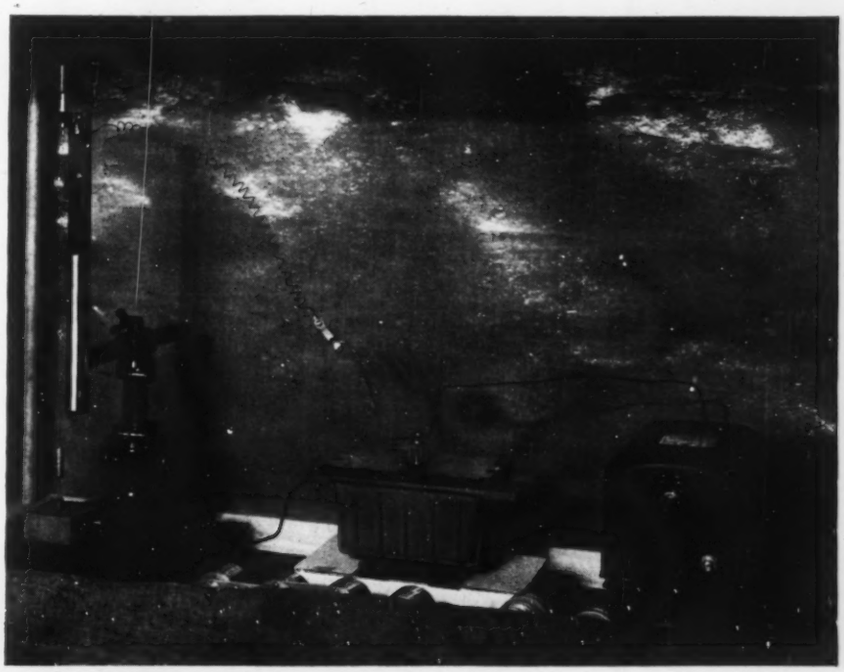
of 1,000,000 beam candlepower when visibility is better. These lamps together with neon units and approach lights in the system may be so adjusted or used in combinations to give any intensity desired down to about 100 candlepower. A partial installation of the system has been tested at Cleveland.

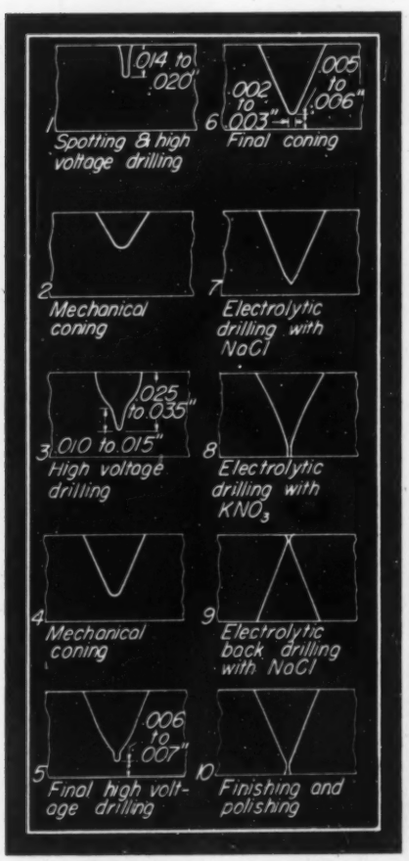
Diamond dies drilled by a new electrical method eliminate almost 100 manhours in making dies for shaping fine wires. The new method developed at the National Bureau of Standards replaces the older mechanical die cutting method with high-voltage drilling followed by electrolytic drilling. Equipment used for high-voltage drilling is shown at right and for electrolytic drilling at right below.

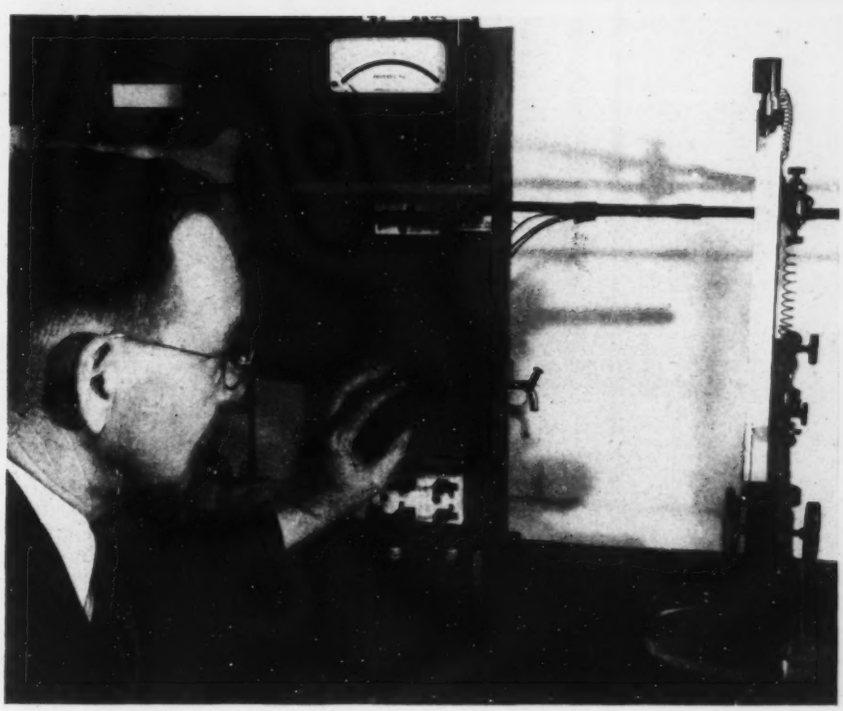
Five surface areas are employed in a diamond die: Primary cone, secondary cone, reduction cone, bearing, and exit cone. The primary cone is drilled with high-voltage sparks formed at the point of a 0.02-inch needle electrode in contact with the face of the diamond. The sparks release the energy stored in a condenser which has been charged through a "quenched" gap consisting of a number of very small gaps in series.

Secondary cone is formed by the action of a low-voltage spark in an electrolytic solution which just covers the diamond. A platinum-iridium needle, resting lightly on the diamond, sparks when low voltage is applied between the needle and a second electrode in the solution, forming a smooth-walled conical hole under the needle. Shape and angle are controlled by the type of electrolyte while the hole size is governed by the pressure on the needle.

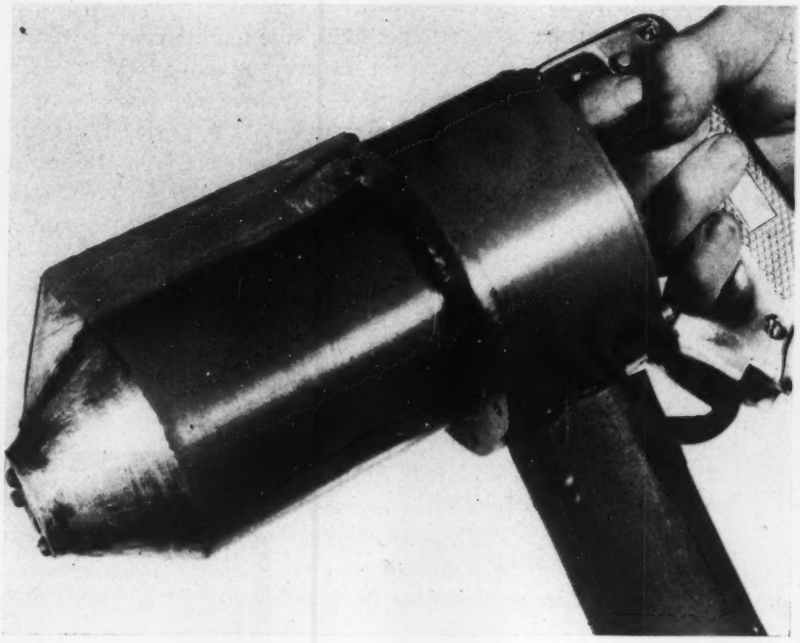
Consisting essentially of ten steps, as shown in the sketches, left bottom, for a typical die, diamond





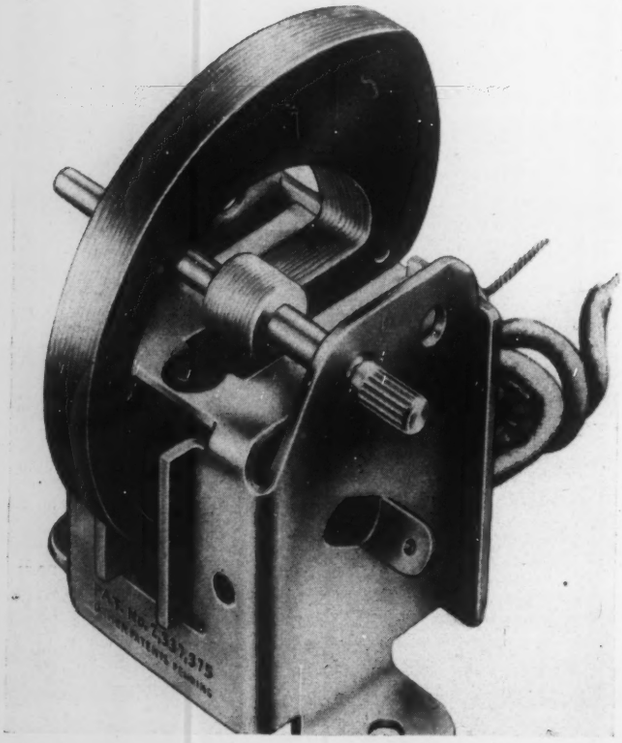


die making uses some mechanical drilling. This drilling is performed with diamond powder in a gelatin solution as the abrasive. The operations illustrated in the sketches take 7 to 15 hours, depending on the type of die. Actual man-hours are considerably less and average about 2 man-hours per die because almost every stage in the process is easily adaptable to multiple production.

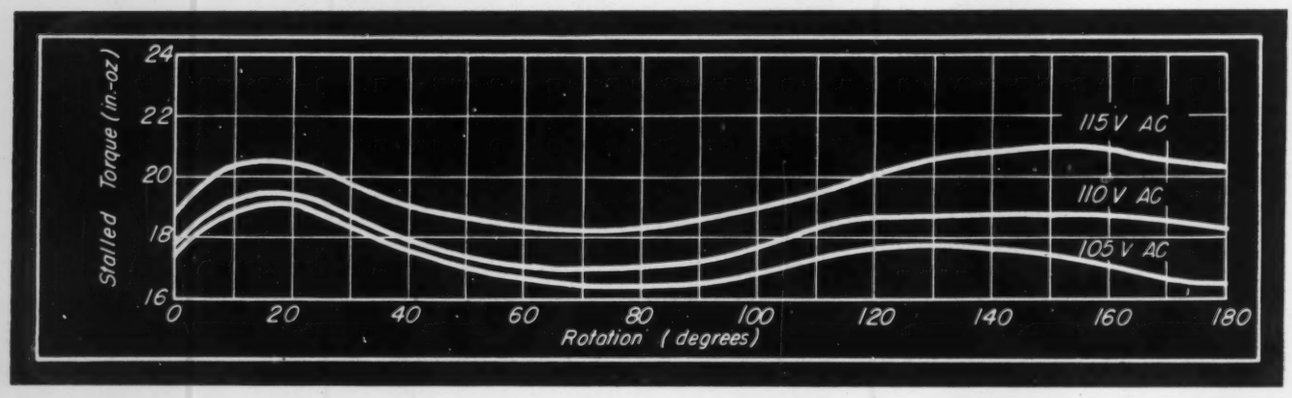


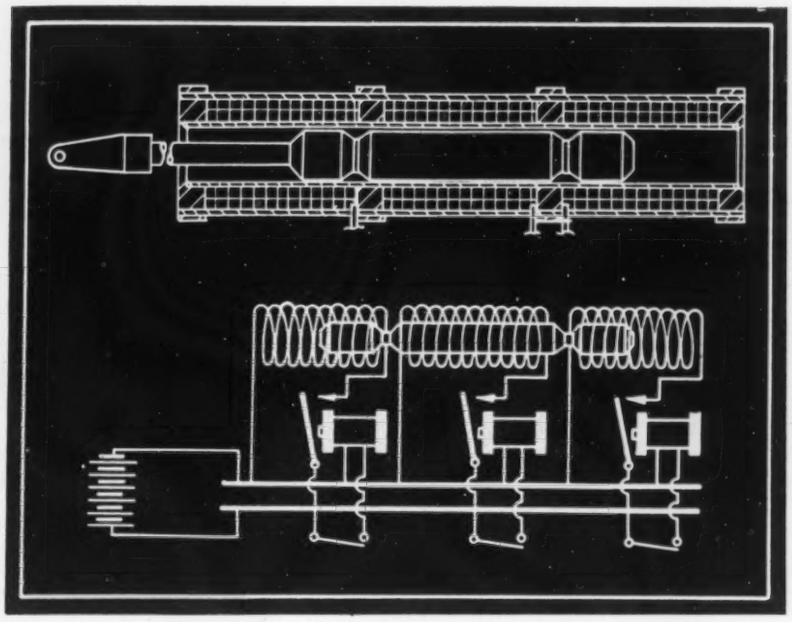
Portable inductor gun shown at right, permits bringing the heat to the work instead of the work to the heat as in conventional induction heating equipment. Designed by The Ohio Crankshaft Co., it is particularly adaptable to large and cumbersome assemblies where many spot heats are required or to short production runs where it is uneconomical to provide a special inductor coil for each part to be treated.

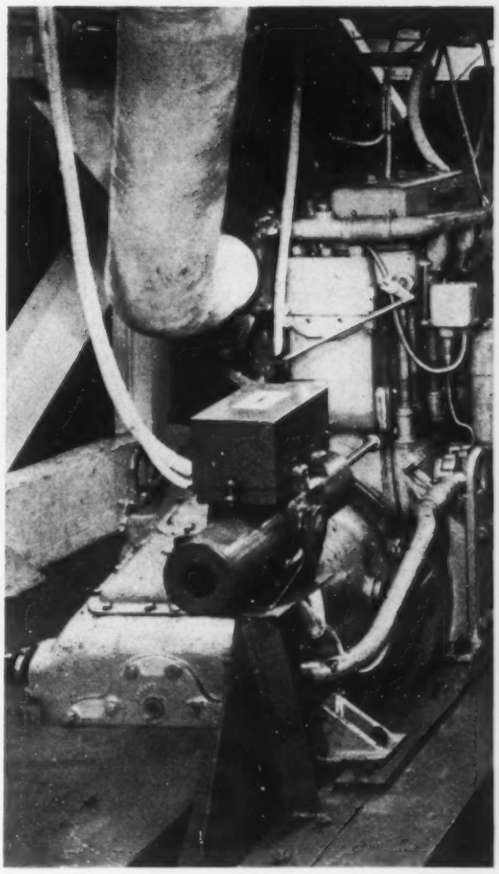
Utilizing a multiple-turn coil to obtain high flux density with relatively low current supply, the gun is controlled by a simple trigger switch. Long leads of moderate dimensions transmit power from a 10,000-cycle induction heating unit to the gun.



Constant torque throughout its 180 degrees of rotation is developed by the swing armature unit shown, left, in the de-energized position with the tip of the armature within the magnetic field. Because the unit has a gradually increasing armature thickness, the torque characteristics shown below are obtained. Designed by Radio Condenser Co., these units can be used to exert torque in either direction of rotation when mounted in opposite positions on a common shaft.



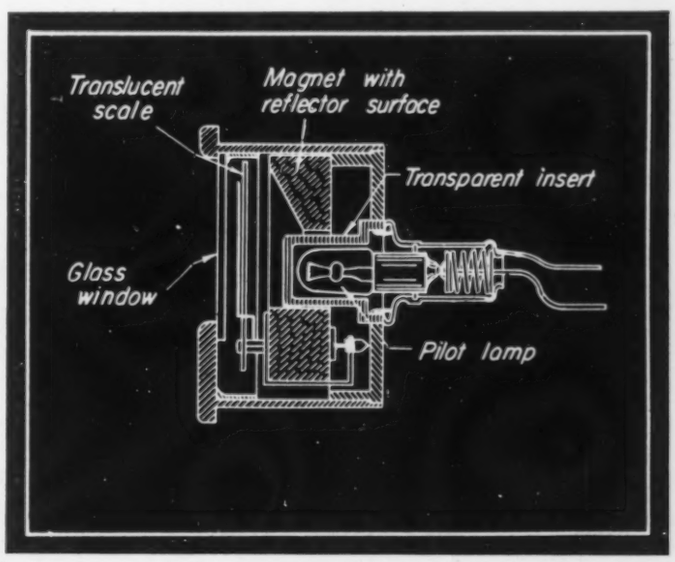




Three-position solenoid controls forward, neutral and reverse positions of ship propulsion gears as shown in the photograph, above right. Consisting of three coils of copper wire wound over an insulated brass tube, the unit is manufactured by the Marine division of the Kirsten Pipe Co. and is illustrated schematically above. Each coil is separated by a steel pole piece, the assembly being enclosed in a shell of steel tubing. The solenoid armature, actuating the clutch lever, operates inside the brass tubing. With this method of operating three interlocked solenoids in one housing, a three position actuator is obtained which is not dependent on a spring or gravity system for its motivating power to desired positions.

Armature is moved into one of the three positions by the magnetic field set up when one of the three coils is energized and remains in that position after the coil is de-energized. To move the armature into one of the other two positions, the proper coil is energized. Desired action is obtained by reducing the cross-sectional area of the armature at a point adjacent to each end of the core so that the solenoid will have maximum pull at the positions desired. This system greatly simplifies remote-control installation between the pilot house and engine room. Although the current consumption of the solenoid is high its duration is only momentary and therefore the load on the battery is small and does not require increased battery capacity over normal operating requirements.

Dial illumination by back lighting a translucent scale, achieved without the usual thermal currents introducing dust and foreign matter into delicate mechanisms, is illustrated in the sectional drawing below. A transparent lucite insert for the lamp cavity seals the opening against dust and also limits the size of the bulb which may be employed, safeguarding the instrument from undue heat. Even illumination across the dial is provided by shaping the front face of an Alnico permanent magnet like a reflector.



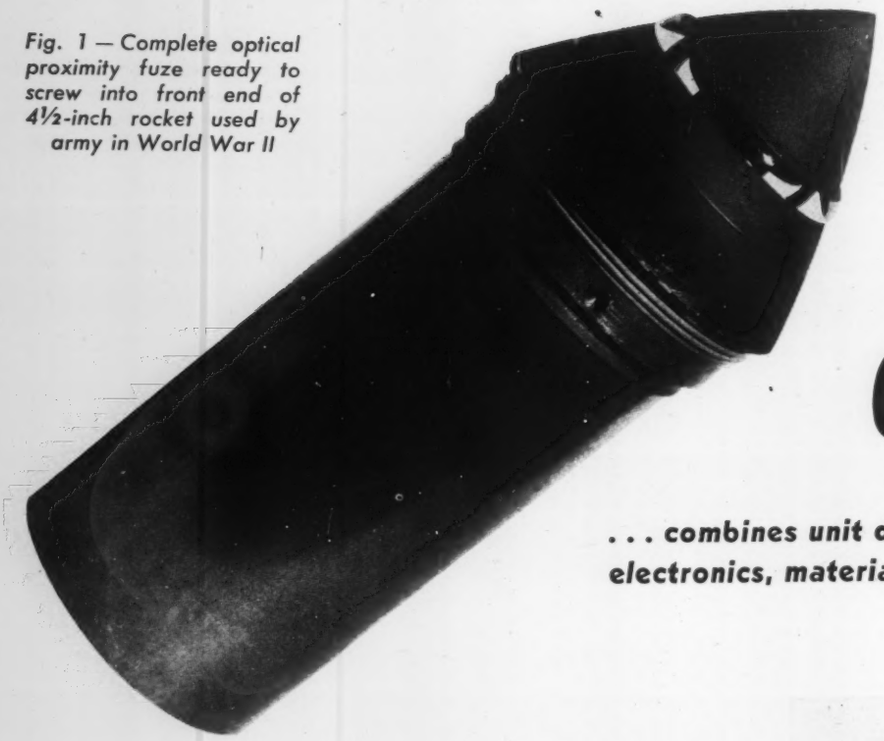


Fig. 1 — Complete optical proximity fuze ready to screw into front end of 4½-inch rocket used by army in World War II

By Frank A. Zupa
Bell Telephone Laboratories
New York 14

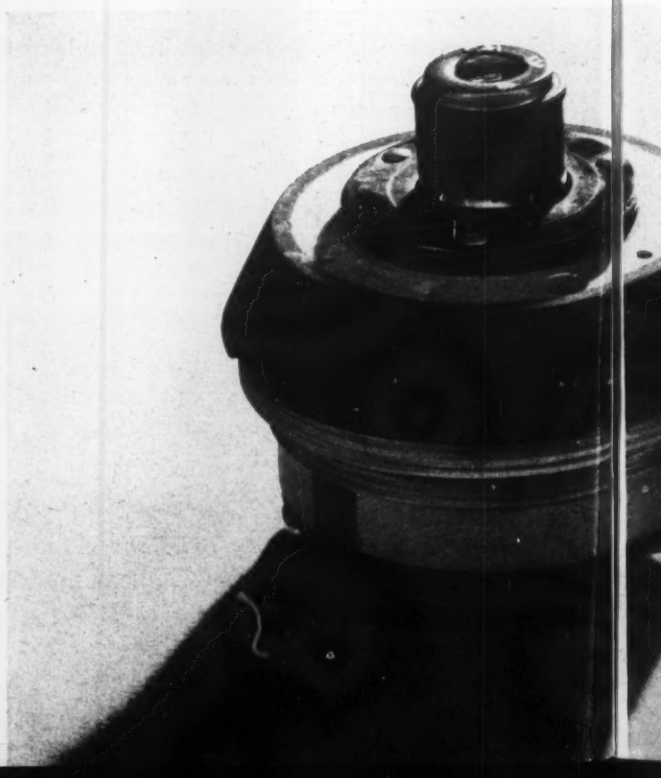
Optical Prox

. . . combines unit designs based on the latest in electronics, materials and processing knowledge

EFFECTIVENESS never before achieved was imparted to the Army's 4½-inch rocket during the recent war by the optical proximity fuze shown in *Fig.* 1. As its name indicates, this fuze is used to detonate the explosive charge in a projectile upon reception of a light signal obtained when the projectile is in close proximity of the target.

Theoretically a proximity fuze is considered to be the perfect time fuze because its timing, in effect, is automatically regulated by the target itself when the latter appears within the lethal range of the projectile. In the case of the older types of fuzes which are preset for their time of operation, although the trajectory of the projectile places the target within its lethal range, comparatively small deviations in the fuze timing mechanism, or errors in the calculated time which is preset in the fuze, often have been found to cause the projectile to explode at a harmless distance from the target. The need for accurate timing of the fuze is evident from the fact that with an error of only 1/10-second, even a low-velocity projectile will be more than 100 feet off its mark when it explodes.

Fig. 2--Above—Toroidal lens (glossy annular ring) is intgeral part of Lucite plastics nose cap



Toroidal Lens Is Integral Part of Nose Cap

The fuze assembly consists of a toroidal lens, a photocell, an amplifier, a battery and a selective inertia type switch. The toroidal lens is an integral part of the conical nose cap which completely encloses the photocell unit. This photocell is mounted on a phenolic plastic base riveted to the die-cast amplifier housing. The conical nose cap is a one-piece injection-molded part with internal screw threads which screw onto the threaded shoulder of the phenolic plastic base.

Mounted in a drilled wooden block, the amplifier components are surface wired, and the block is mounted on a phenolic-fiber disk equipped with radio-tube base pins which serve as the amplifier terminals. This amplifier assembly, electrically wired to the photocell unit, is held in place in the die-cast housing by screws. Battery

roximity Fuze

and switch are two separate cylindrically shaped units having the same outside diameter as that of the amplifier base. The amplifier and the switch terminal pins plug into sockets on opposite ends of the battery unit. A cylindrical cover, enclosing the switch and battery units, screws onto the die-cast housing. It also contains a chamber for the booster charge. Supporting the entire fuze assembly, the die-cast housing screws into the front end of the projectile. Exposed surfaces of the nose cap and die-cast housing are shaped to conform exactly to the ogive curvature of the projectile.

Operation or function of the basic components of the fuze may be broadly described as follows: The toroidal lens collects light from all transverse directions during the flight of the projectile and directs it through the annular transparent section of the photocell tube to the surface of the cathode within the photocell. The photocell transforms the light energy into electrical energy which is then applied to the input side of the amplifier. The amplifier circuit, however, is arranged to function so that its output voltage is negligible until there is a sudden change in the amount of light received by the toroidal lens, a change which is brought about by the sudden appearance of the target in the vicinity of the projectile.

It should be realized that when the projectile approaches the target, the latter acts as a partial screen which has the effect of reducing the amount of light falling upon the lens, and in turn, on the photocell cathode. The resulting sudden change in the electrical energy on the input side of the amplifier is then amplified to develop the voltage value which is necessary to cause a discharge in a thyratron tube which, in turn, starts the chain of action that ignites the explosive charge in the projectile. Change in amount of light entering the lens necessary to operate the thyratron tube need be but an extremely small percentage of the total light entering the lens, regardless of the prevailing light level from dawn to dusk. The switch mechanism is arranged to connect the battery to the amplifier circuit after the projectile has been fired from its launching tube but before it approaches the target. Forces developed by the firing of the projectile are utilized for the operation of the switch. In addition, the fuze is equipped with a self-destruction arrangement so that if the projectile misses the target it will be expended before reaching the ground. This feature, of course, is a desirable safeguard if the projectiles are used against aircraft over one's own territory.

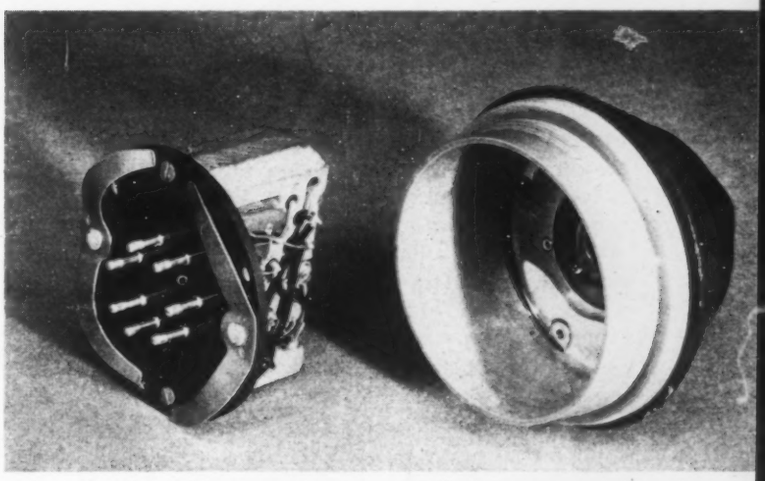
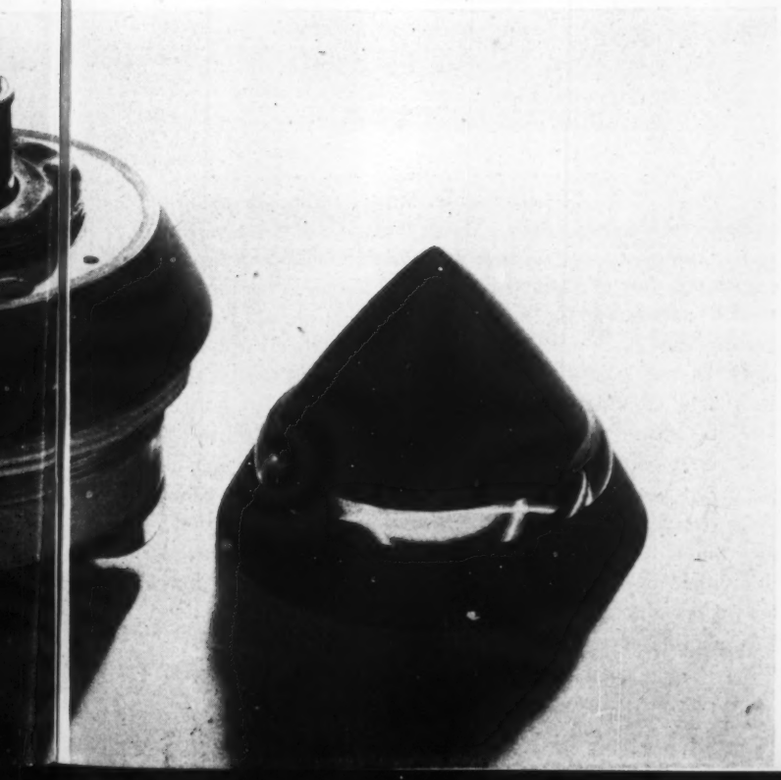


Fig. 4—Die-cast housing, right, mounts nose cap, photocell unit, and amplifier which is shown at the left

Fig. 3—Below—Head of fuze with nose cap removed. Cylindrical slit on photocell lies just above the phenol plastic base which also serves to mount the nose cap



Components Subject to High Acceleration Forces

Before entering into a discussion of the design and construction of the main parts of the optical proximity fuze, it is of interest to note that this device was required to withstand forces due to the acceleration associated with the propulsion of rockets. These forces were specified by Army Ordnance as being 1000 times those due to gravity. In other words, when the rocket is fired, all fuze components and their mountings are subjected to forces equal to 1000 times their weight when at rest. Limitations were also placed on the total weight and volume of the fuze in order to provide more of the explosive load and obtain

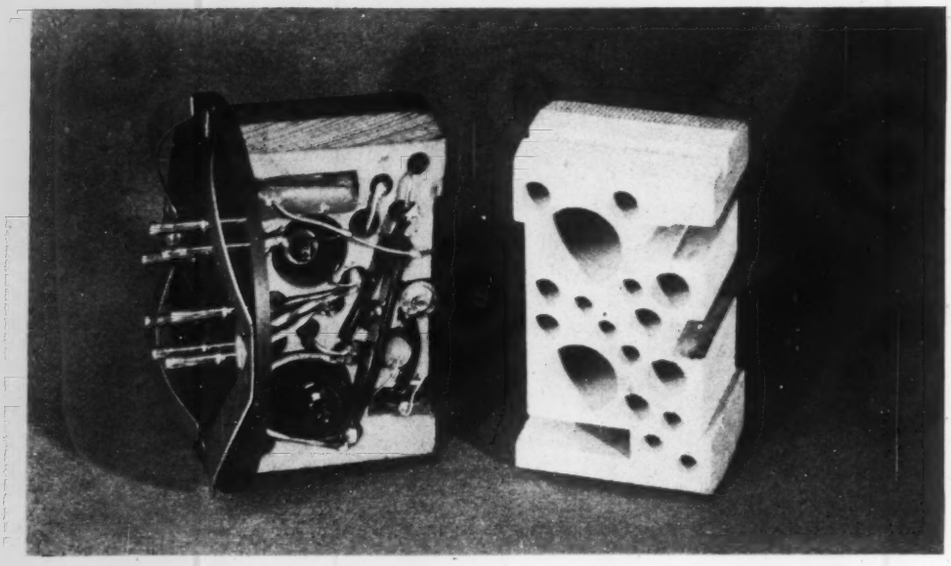


Fig. 5—Left—All elements of amplifier, left, are fitted into wood block and surface wired. Wood block before assembly is shown at right

Fig. 6—Below—Optical proximity fuze assembly before battery, switch and cylindrical cover are attached

greater range for the projectile. Distribution of the mass also had to be controlled so that the center of gravity of the completed fuze was very close to its longitudinal axis, in order to minimize the effect of unbalance on the trajectory of the projectile. The light sensitivity and electrical operating requirements for the fuze had to be met after exposure to extreme atmospheric conditions ranging from a temperature of −40 F to +140 F. Since the fuze was required in large numbers, its design had to be suitable for rapid production and at low cost.

Nose Cap Demanded Rigid Molding Control

The toroidal lens, *Fig.* 2, is an integral part of the nose cap which is made of optically clear methyl methacrylate, commercially known as Lucite. It was manufactured by injection molding to the final dimensions, and no polishing of the lens surfaces was required after molding. No serious difficulty was experienced in obtaining a clear homogeneous mass but rigid thermal control of the molding cycle had to be maintained in order to meet the close dimensional tolerances on the toroidal lens and a close fit on the screw threads in relation to the associated screw threads on the phenolic plastic part. Screw threads on both parts were slightly tapered to facilitate withdrawal of the threaded portion of the respective molding dies.

Portions of the surfaces on the nose cap that had to be opaque to light were coated with an optically black finish by spraying. Considerable difficulty was experienced before a suitable paint was found which was not destructive to the Lucite. Some paints caused slow disintegration or crazing. Each completed Lucite nose cap was inspected for opaqueness of the painted surfaces and for light-angle transmission requirements on the toroidal lens. The lens was required to transmit only the light which came through an angle of a few degrees throughout its circumferential surface, the median of that angle being at a fixed angle with the fuze longitudinal axis.

To meet the light-angle operating requirements for the fuze—a requirement which governed the most effective firing position of the projectile relative to its target—it was found necessary to interpose a narrow cylindrical slit opening between the photocell and the toroidal lens, *Fig.* 3.

The slit had to be accurately located relative to the cathode in the photocell. Many designs were conceived in the search for a construction which would require no adjustment for its position or size. The design which succeeded in meeting the requirements was obtained by first coating the glass tube on the photocell with an optically black lacquer and then cutting away part of the coating at a fixed distance from the base cap of the photocell. This technique was new and it required rather skillful development work before it was reduced to a simple manufacturing process without injury to the photocell tube. With the slit and lens arrangement the photocell cathode was made to "see" the target at an angle which placed the target in the densest part of the fragmentation pattern when the projectile exploded.

Design of the amplifier housing, *Fig.* 4, proved to be quite an interesting problem because it was required to have a high degree of structural stability under the stresses encountered in storage, shipment and usage. It had to withstand shocks and extreme temperatures without cracking or distortion which might break the electrical connections between the amplifier assembly and the photocell. In addition, it had to be waterproof and have free-running screw threads of adequate strength for a secure assembly to the rocket casing. These requirements had to be met with a minimum of weight and a symmetrical distribution of mass. The design finally adopted was a one-piece die casting using zinc alloy 23, ASTM B86-38T.

In the design of the amplifier assembly, special consideration had to be given to the relative position of the resistors, condensers, tubes and wiring, in order to avoid objectionable capacitance coupling. The components had to be located in a geometric pattern which did not vary from one assembly to another in production. Also, the assembly had to withstand the high acceleration forces already mentioned. This was accomplished by individually mounting each component in a suitable hole in an impregnated wooden block, *Fig.* 5. These blocks were produced economically by the simple processes of gang sawing and jig drilling. The components were connected by surface wiring on two sides of the block, the units being produced on a straight-line assembly basis. Supply of electronic tubes was extremely limited owing to the large demands of other similar ordnance devices, and for this reason tubes which had various degrees of gain characteristics had to be used by matching them with suitable grid-bias resistors and by-pass condensers before they reached the amplifier assembly line.

Components Sealed in Wax

After the amplifier assembly was mounted in the die-cast housing and connected to the photocell tube, the housing was completely filled with a ductile mineral wax. The type of wax and the potting process were carefully chosen to obtain a water-proof and shock-resistant assembly for the amplifier components and wiring. One of the difficulties which had to be overcome was the separation of the wax from the walls of the housing at low temperatures, a condition which would react as a loose mass under shock. Assembly of the fuze prior to attachment of the cylinder which houses the switch, battery and booster charge, is pictured in *Fig.* 6.

The cover which enclosed the battery, switch and booster charge units was made of thin-walled seamless steel tubing with separately attached base cap on one end and a heavy steel ring on the other. The end pieces were attached by spot welding and brazing processes to obtain waterproof joints. The ring then was threaded on the inside for screwing onto the die-cast housing. This design of cover withstood a minimum of 1500 pounds load distributed on the inside surface of the base cap when the cover was held by the screw threads on a die-cast housing.

Opportunity for America's Inventors

A LIST of twenty-five technical problems requiring solution by the Army, Navy and Coast Guard has been released by the National Inventors Council. Anyone having what he believes is practical information on or a solution to these problems is urged to forward his proposals to the National Inventors Council, Department of Commerce, Washington 25, D. C.

Here are some of the new inventions our armed forces need:

1. Light-weight, low-horsepower (less than 200) gas turbines whose economy of operation would be comparable or better than conventional internal combustion engines
2. Ultra light-weight gasoline engines with ratings as low as one and up to five horsepower, and capable of continuous operation with minimum maintenance
3. Means for or materials for combating corrosion or deterioration by fungi of military equipment
4. Materials having improved low-temperature properties for construction of equipment for arctic use
5. Standby heaters which will start readily and operate satisfactorily in a minimum temperature of −65 F and in winds of 50 miles per hour (for arctic use)
6. Simpler, smoother, easier-to-operate and maintain power transmissions of infinitely variable speeds suitable for railway equipment including locomotive service with horsepower ratings up to 700 and 1300
7. A draft gage to provide accurate readings while a vessel is at sea
8. An accurate visual, recording roll indicator for installation on vessels
9. A glider-borne lifeboat which may be launched from water or land and towed by powered aircraft to persons in distress in the water
10. A suitable whistle for diesel-propelled vessels under 100 feet in length
11. A line-throwing gun or rocket equipment which will exceed in performance and be safer and lighter than existing equipment
12. A device to detect the presence of fog, rain squalls, or snow which reduces visibility in the vicinity of a light vessel to less than one mile. Device should indicate presence of a fog bank 3 or 4 miles away from the vessel.
13. A light-weight, high-speed diesel engine of approximately 8 to 10 horsepower, weighing not over 15 pounds per brake horsepower
14. A land-going lifeboat for coastal (inshore) life saving and assistance work operating from Coast Guard beach stations.

A full statement of the complete list of twenty-five technical problems may be obtained by writing to the council. All proposals received will be studied by the council and its operating staff and those recommended will be sent to the proper branch of the Army, Navy, or Coast Guard for further examination. Inventors may disclose their proposals to the council without jeopardizing their patent rights. All disclosures will be dated and kept in a confidential file. On the other hand, disclosure to the council does not provide the protection of a patent, and the inventor must file the usual patent application with the Patent Office if and when he desires such protection.

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Comparing Plastics

. . . with respect to their mechanical properties and those of common structural metals

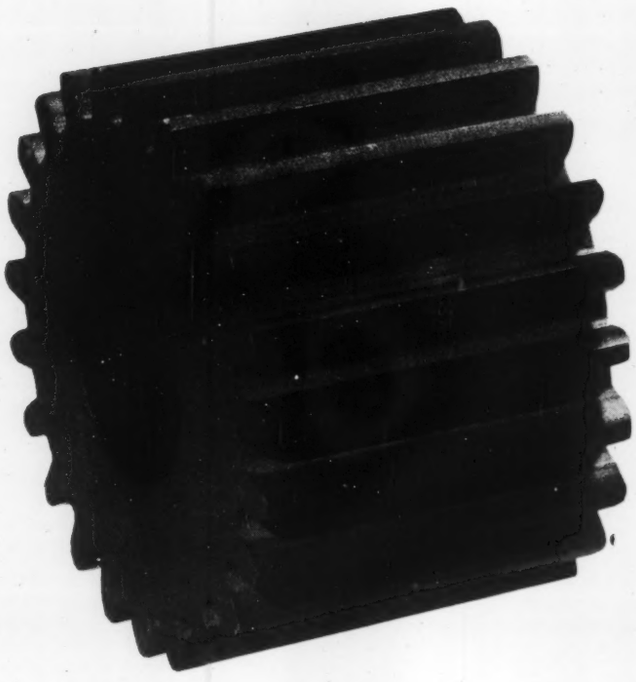

Fig. 1—Above—Fabric-filled plastics gear has high damping capacity, making it excellent where quietness is required

WITH each year there is an increasing use of plastics, in industrial equipment and home appliances. Agitators for washing machines, telephone handsets, spinning buckets in the rayon industry, distributor heads, and gears, *Fig.* 1, are a few examples of this trend. Among the properties of plastics that have made possible these uses are:

1. Easy fabrication. Molding powders are readily formed in steel molds to produce complicated parts to close tolerances without the need of an expensive finishing operation. Large and small irregular shapes are easily produced from plastics laminates at rapid rates
2. Low specific gravity, averaging 1.4 and rarely exceeding 2.0
3. Chemical resistance
4. Superior dielectric properties
5. Appearance—gloss, transparent or warm color
6. Feel—warm due to low thermal conductivity
7. Quietness in handling because of high damping.

In questions relating to machine design all the attributes listed above may influence the designer to prefer plastics for the part under consideration but his final decision may often be based on the cost in combination with purely mechanical properties, like flexural strength, afforded by the plastics being considered. The cost of a plastics part in comparison with the cost of a similar part in another material must be solved as a specific problem which can best be answered by estimates from fabricators. The purpose of this article is to provide a ready reference of these mechanical properties that have such an important bearing on the designer's decision.

Data on the mechanical properties of plastics types have been slow in evolving but they are now fairly complete after the rapid progress of the past six years. However, they are scattered widely through the literature so that a compilation in one place is appropriate at this time.

The values given in TABLE I are averages determined at standard testing conditions of 77 F and 50 per cent relative humidity unless otherwise stated. A steel and an aluminum alloy are included for comparison. It is believed that no detailed explanation is needed of either the practical significance or the method of measuring the properties listed. The references listed at the end will supply detailed information if such is desired. However, it is thought desirable to discuss a few of these materials and their properties:

Three Basic Groups of Plastics

MATERIALS: Although there are hundreds of plastics in commercial use they are adequately represented by the several materials listed. These have been divided into three basic types:

Thermosetting: Phenolics have been chosen for the table. However, materials based on melamine resin and on urea resin are similar to the phenolic materials containing the same fillers. The lighter color of these resins permits the production of pastel molding.

Thermoplastic: Modified polystyrenes have been developed to improve the heat resistance as much as 30 C and reduce somewhat the brittleness of polystyrene. The cellulose acetate listed is a medium grade. Harder acetate

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has a higher tensile strength, higher modulus of elasticity and less elongation under tension. Softer acetate varies from medium acetate in the opposite direction. Ethyl cellulose, cellulose acetate-butyrate and cellulose propionate may also vary in properties according to the formulation. Generally medium grades resemble the medium grade of cellulose acetate. The properties of thermoplastics vary with the method of molding. The figures given are conservative ones for injection-molded samples.

TABLE I

Comparison of Beams of Same Width and Load Capacity

Material	Depth	Weight	Stiffness	Flexural Work, Unnotched (Impact Resistance)
Steel	1.0	1.0	1.0	1.0
Woodflour-Phenolic	2.8	0.49	0.73	0.08
Canvas Laminate	1.9	0.33	0.30	0.5
Aluminum	1.0	0.34	0.35	0.7

With compression molding there is usually a moderate decline in mechanical strength.

The polymethacrylate in the tabulation is a typical one; properties vary with formulation. Rigid Vinyl plastic sheet possesses similar mechanical properties. Thermoplastics like polyethylene and highly plasticized vinyls cannot be called rigid, because of their low modulus of elasticity, and have been omitted.

Laminates: Grades XX and L are standard mechanical laminates containing about 50 per cent phenolic resin. Other resins give somewhat similar laminates. The Fiberglas laminate is bonded with a phenolic resin. Properties will vary somewhat with resin type and amount.

For the design engineer, an understanding of the physical properties of plastics is perhaps more difficult that is the case with metals. Certainly plastics do not follow the metallurgical rules of metals where changes in physical properties are concerned. Examples of variations follow:

STRESS-STRAIN RELATIONS: Tensile stress-strain curves for all rigid plastics except cellulosic compounds are shown in *Fig.* 2. The curve for cellulose acetate is shown in *Fig.* 3. As indicated in these illustrations if a 0.2 per cent offset point exists in tension or flexure, it is at least 60 per cent of the ultimate strength for both types. If the compressive strength is much higher than the tensile strength the 0.2 per cent offset stress in compression is only 30 to 50 per cent of the ultimate compressive strength and there is much more plastic strain than in tension; otherwise tensile and compressive stress-strain curves are similar. Modulus of elasticity is nearly constant (usually $\pm$ 20 per cent) whether loading is tensile, flexural or compressive for all materials.

NOTCH SENSITIVITY: This value describes the weakening effect in flexural loading of a notch 0.1-inch deep with a radius 0.01-inch at the bottom, and is given by

$$\text{Notch Sensitivity} = P/P_n$$

where P is the breaking load for a 0.4-inch thick flat bar, and P_n *is* the breaking load for a 0.5-inch thick bar with a 0.1-inch deep notch. Notch sensitivity tends to reduce all dynamic and static strengths where the part contains small holes, sharp corners, sudden changes in section, screw threads, etc. Thermoplastics are much more notch sensitive when the notch is cut or milled than when it is molded.

IMPACT RESISTANCE: The Izod impact test on a ½ by ½-inch specimen containing a standard milled notch,

Fig. 2—Tensile stress-strain curve for all structural plastics except cellulosic compounds

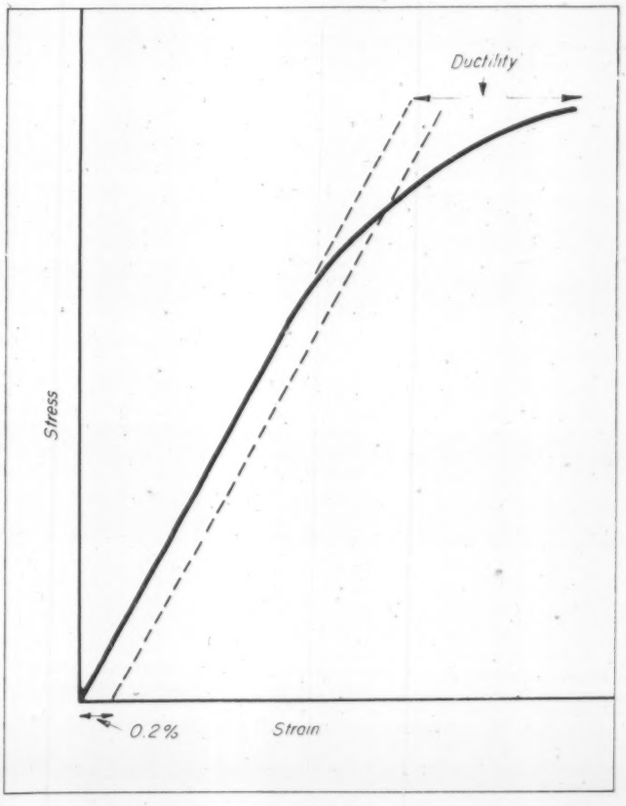
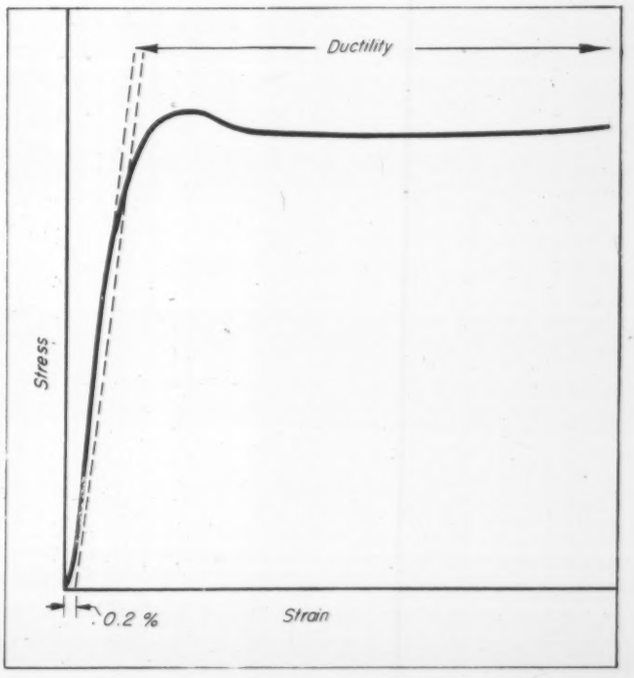


Fig. 3—Tensile stress-strain curve for cellulose acetate has deflection point like metals



of the dimensions given under Notch Sensitivity in TABLE II, is often a misleading criterion of the capabilities of a material. A more satisfactory value is flexural work to break (i.e., the area under a flexural load-deflection curve). The value for an unnotched bar, ½ by ½-inch on a 4-inch span, applies in practice where the molded object contains no notches or equivalents in the form of sharp corners, etc. Flexural work to break, notched, is determined under similar conditions, except that the bar contains a standard notch, and it is a measure of resistance to impact of objects that do contain notches and equivalents. These two values of work to break provide quite a different evaluation than the Izod test and they demonstrate clearly the weakening caused by a notch when the notch sensitivity is high. However, where the ductility is high, flexural work may not correspond so closely with actual resistance to impact. The flexural work to break for steel and aluminum is the approximate work to cause a yield of 0.2-inch at the center of a ½ by ½-inch bar on a 4-inch span. Both have, practically, failed at that stage.

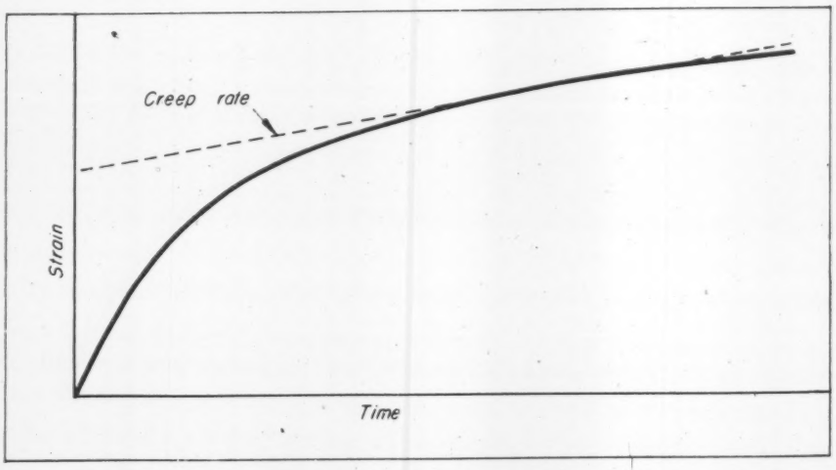


Fig. 4—Creep curve for plastics at room temperature. Period of rapid creep is followed with phase in which creep is almost linear with time

FATIGUE STRENGTH: With metals, the fatigue stress to cause failure often becomes constant after 10^6 cyles and this stress is then called the fatigue strength or endurance limit. With plastics the endurance limit is often not sharply defined and there is a tendency for the stress to cause failure to fall slowly after 10^6 cycles. The fatigue strength given is based on experiments carried to 10^8 cycles at speeds of stressing varying from 1800 to 10,000 rpm. Speed of testing may not greatly affect fatigue strength. Some plastics tend to rise in temperature during fatigue loading because of high internal damping; consequently the modulus of elasticity may fall somewhat. This is more marked with the thermoplastics.

DAMPING CAPACITY: The data presented are calculated from the decay of vibrations corresponding to low stresses. Where the stress is sustained at a level near the fatigue

TABLE II Properties

Material	Strength			Modulus of Elasticity (psi x 10^{-6})	Ductility in Tension (per cent)	Notch Sensitivity	Flexural Work to Break		Izod Impact Strength (ft-lb/in.)	Fatigue Strength (Bending) (psi)	Damping Capacity (per cent)	Hardness Rockwell M or Brinell B
	Tensile (psi)	Flexural (psi)	Compressive (psi)				Unnotched (ft-lb)	Notched (ft-lb)				
Thermosetting												
Woodflour-phenolic	7500	10000	27000	1.0	<0.2	2.0	0.6	0.07	0.3	3600	14	M-115
Fabric-phenolic	6500	10000	27000	1.0	0.2-1.0	1.0	1.0	0.9	3.5	3800	15	M-110
Asbestos-phenolic	5000	7000	22000	1.8	<0.2	1.6	0.2	0.04	0.3	2700	11	M-112
Mica-phenolic	6000	8000	7500	3.5	<0.2	1.4	0.1	0.03	0.4	—	7	M-107
Thermoplastic												
Polystyrene	6000	15000	13000	0.5	0-0.5	1.0	3.5	0.5	0.3	1500	6	M-87
Cellulose-acetate	4500	7000	14000	0.2	36	1.0	—	—	1.4	1000	>30	M-56
Poly-methacrylate	8000	12000	12000	0.4	3	—	—	—	0.45	2000	23	M-80
Laminates												
Paper Laminate, XX	17000	18000	24000	1.5	1.0	2.0	1.9	0.3	2.2	5000	11	M-112
Canvas Laminate, L	16000	22000	26000	1.3	0.8	1.4	4.9	0.6	4.4	5000	13	M-106
Fiberglas Laminate	39000	60000	28000	2.4	0.2-1.0	1.4	7	2	22	12000	10	—
Metals												
Steel, SAE 1025	80000	—	—	30	18	1.0	21	—	+50	50000	1.1	B-163
Aluminum, 17ST	60000	—	—	10	20	1.0	16	—	—	15000	0.5	B-15

*Average data on each material classification are given. For data on specific materials refer to SPI standards.

strength it appears that damping capacity may be much higher. However, the only available data are too few for comparison. Percent damping, ψ, is defined as

$$\psi = (E_a/E)\ 100$$

where noise must be reduced and for this reason plastics equals the energy content at the start of the cycle.

The possession of a high damping capacity is desirable where noise must be reduced and for this reason plastics gears, *Fig.* 1, for example, are often preferred to metal gears or are used in combination with metal gears. High damping capacity is also an advantage when vibratory loads at the resonant frequency must be resisted. At resonance a low applied load can cause a high stress. For a given load this stress is higher the lower the damping capacity. High damping capacity thus provides a factor of safety against failure at resonance.

Specific Gravity: If a plastics object is to be as strong as if it were metal it is necessary to use much more material. However, the low specific gravity of the plastics means that there may be no actual increase in weight and in some instances a reduction.

For a member under tension the area of wood-flour phenolic material would have to be 80,000/7500 or 10.7 times that of steel and the weight would be 10.7 (1.36/7.8) or 1.85 times as much. Similarly the area and weight ratios would be 5.0 and 0.86, respectively, for canvas laminate to steel and 1.33 and 0.46 for aluminum to steel. These members having strengths equal to that of a steel member would exhibit the following tensile stiffnesses (steel being 1.0): wood-flour phenolic 10.7 (1.0/30) or 0.36, canvas laminate 0.22, aluminum 0.44.

Similar comparison can be made for flexural loading. If a practical flexural strength of steel is assumed to be equal to the tensile strength (80,000 psi) the depth of a member of equal width and equal strength for wood-flour phenolic material having a flexural strength of 10,000 psi would be $(80{,}000/10{,}000)^{0.5}$ or 2.8 times as much.

The weight would be 2.8 (1.36/7.8) or 0.49 as much for the plastic as for steel. Stiffness, being proportional to the modulus multiplied by the cube of depth, is $(1.0 \times 10^6 \times 2.8^3)/(30 \times 10^6 \times 1.0^3)$ or 0.73 for the plastics, compared with 1.0 for steel. Flexural work, being proportional to depth, is 2.8 × 0.6/1.0 × 21, or 0.08 for the plastic compared with 1.0 for steel. Figures for other materials are shown in Table I.

Long-Time Tensile: Plastics resemble many other materials in that long-time strength at room temperature is considerably lower than the tensile strength. This may be an important matter in design calculations. The long-time strength given is a stress that can be borne safely for two years, based on an extrapolation of creep data, *Fig.* 4. Creep curves for plastics at room temperature are somewhat similar to those of metals under low stress where a period of initial rapid creep is succeeded by a phase in which creep is almost linear with time. Many creep curves do not go beyond 1000 hours so that the creep rate given may be somewhat high.

At higher temperatures the creep curves for thermoplastics resemble those at room temperature except that the creep rate is much greater. But with thermosetting molding materials and with laminates based on thermosetting resins the tendency to creep is offset by the tendency to shrink (arising from a loss of volatile matter). The actual creep curve resulting from the addition of these two effects at 192 F is somewhat irregular and the total elongation after 100 hours is generally less than that for a similar period and a similar stress at room temperatures. For this reason no creep rates are given at higher temperatures with respect to these materials.

With cellulose acetate the strength is usually limited by the deformation. It could probably sustain a stress of 1500 psi indefinitely but the strength given at room temperature is the stress at which the creep rate does not exceed 0.1 per cent per 1000 hours. There are insufficient data to allow a close estimate of the creep strength of polystyrene and polymethacrylate. It is fairly certain that a minimum figure of 1000 psi

of Typical Plastics

Poisson's Ratio	Specific Gravity	Long Time Tensile at 77 F: Creep Strength (psi)	Long Time Tensile at 77 F: Creep Rate (%/1000 hr)	Strength at Higher Temperatures: Temp. (F)	Strength at Higher Temperatures: Creep (psi)	Strength at Higher Temperatures: Tensile (psi)	Water Distortion 21 days In H_2O (% length chg.)	Coefficient of Thermal Expansion ($\times 10^{-6}$/deg. C)
0.3	1.36	2500	0.04	192	1300	6500	0.1	35
0.3	1.38	2200	0.06	192	1300	6000	0.2	20
0.3	1.9	2000	0.02	192	1300	5000	0.01	18
0.2	1.88	1800	0.005	192	1300	5000	0.01	18
0.3	1.07	+1000	—	125	<1000	5000	0.004	70
—	1.28	1000	0.1	125	—	2500	0.4	120
0.4	1.18	+1000	—	125	<1000	4000	0.04	80
—	1.34	8000	0.1	192	5000	13000	2.0	—
—	1.34	8000	0.05	—	—	14000	0.4	—
—	1.7	—	—	—	—	—	≦0.2	—
0.3	7.8	50000	negligible	800	18900	—	—	11
0.3	2.7	30000	negligible	—	—	—	—	24

holds for both and that at this stress the creep rate is lower than 0.1 per cent per 1000 hours.

At room temperature the creep strength given for both steel and aluminum is the stress at the elastic limit and it is generally accepted that the creep at this stress is negligible for most calculations.

STRENGTH AT HIGHER TEMPERATURES: Creep strength is the stress that can probably be borne indefinitely (2 years) at the temperature cited. The tensile strength is the orthodox tensile strength after an exposure of 3 weeks for the laminates and thermosetting materials and a few hours for the thermoplastics. Some of the tensile data are converted from flexural data. In general these results at higher temperatures do not seem too consistent.

As indicated, the thermoplastics begin to display a loss in strength at 125 F. With few exceptions they creep rapidly under a stress of 200 psi at 200 F. The other plastic materials are more satisfactory in this respect and retain a considerable capacity to bear load at 192 F. Above 300 F most common thermosetting materials and laminates cannot be used with reliance unless mineral is included in the formulation when the permissible temperature rises to 400 F or better.

WATER ABSORPTION: Most of the typical plastics listed in TABLE II absorb water to an extent which may be important when dimensional stability is to be maintained.

The figures presented are for either immersion in water or exposure to a saturated atmosphere for 21 days. The amount of water absorbed is about the same for either treatment. An exposure of this kind for 21 days has an effect that is far more severe than that caused by the sustained humidity of summer. The values for thermosetting materials and for laminates are for specimens ½-inch thick. Those for thermoplastics are based on ¼-inch specimens. Thinner specimens tend to absorb water more rapidly and expand more freely.

Water absorption must be remembered particularly when a plastic product is to be exposed to water on one side only, *Fig.* 5. Warping may occur in service because the wet side tends to expand on absorbing water while the dry side tends to retain its dimensions. Or, if warping is prevented, undesired stresses may arise that are large enough to cause failure. Where the typical materials offer too high a water absorption special formulations with lower absorptions are usually available.

COEFFICIENT OF THERMAL EXPANSION: Approximate values are given in the table and they apply only in the lower temperature ranges up to 125 F. Above this, temperature expansion is often accompanied by shrinkage due to a loss of volatile matter, especially with the thermosetting materials, so that the coefficient becomes meaningless.

The high coefficient of expansion of plastics means that there must be forethought if they are to be used successfully in conjunction with metals in applications where the temperature is variable, *Fig.* 6. Otherwise undersirable stresses or changes in dimension may occur. This is true also where plastic and metal are fabricated together at the molding temperature for plastic and subsequent cooling allows the differing coefficients to express themselves.

Fig. 5—Pump molded of phenolic plastics possesses excellent resistance to water absorption. It is also oil resistant and requires no machining operation after molding

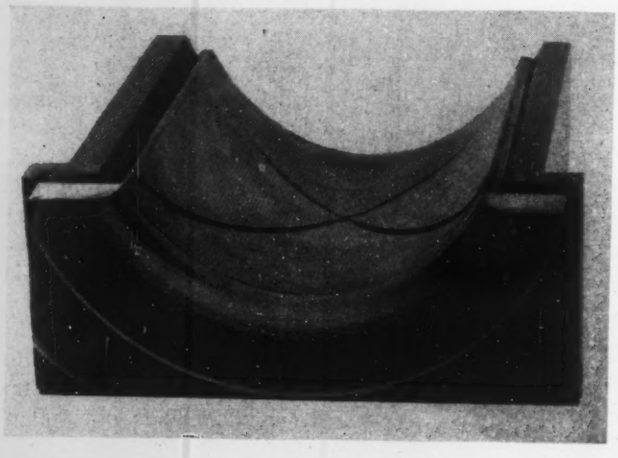


Fig. 6—Plastics bearings give excellent service when carefully designed

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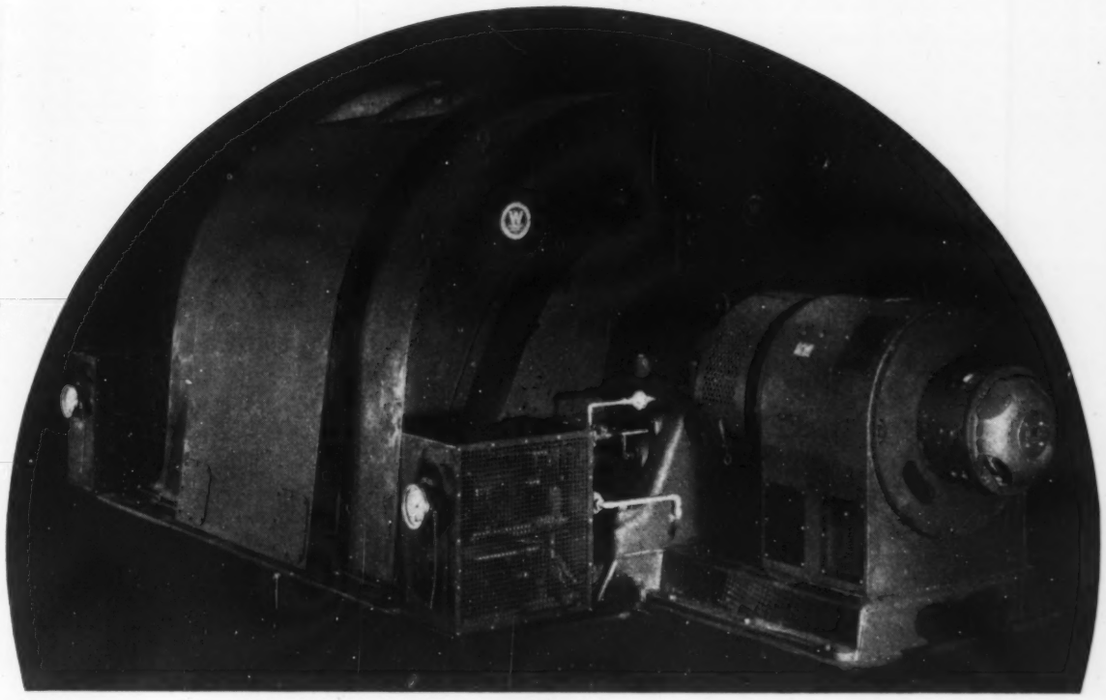

Hydrostatic Lubrication

By Dudley D. Fuller
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Part II—Oil Lifts

SLEEVE bearings of the oil-film type, after being brought up to speed, operate with a high degree of efficiency and reliability. However, difficulties arise where the rotational speed of the journal is too low to maintain a complete hydrodynamic oil film. This condition is especially noticeable at starting, stopping and reversing, or whenever the operating speed falls below a certain minimum. When this occurs the oil film is ruptured and the fluid film condition is replaced by boundary film or greasy type of friction. Frictional drag increases while incipient metal-to-metal contact develops, rapidly worsens and leads to wear of the bearing material.

This condition can be eliminated by introducing high-pressure oil to the area between the bottom of the journal and the bearing. *Fig.* 13. If the pressure and quantity of flow are great enough the shaft, whether it is rotating or not, will be raised and supported by an oil film, *Fig.* 14. Frictional drag may drop to one-tenth or less and in the case of certain kinds of heavy rotational equipment, where

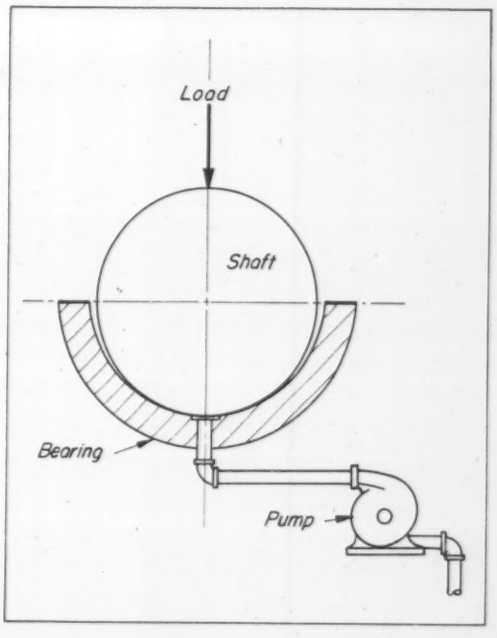

Fig. 13—Top—Starting torque of this synchronous condenser is greatly reduced by use of oil lifts. Each bearing has separate system mounted close to it. Photo, courtesy Westinghouse Electric Corp.

Fig. 14—Right—Diagram illustrating principle of the oil lift

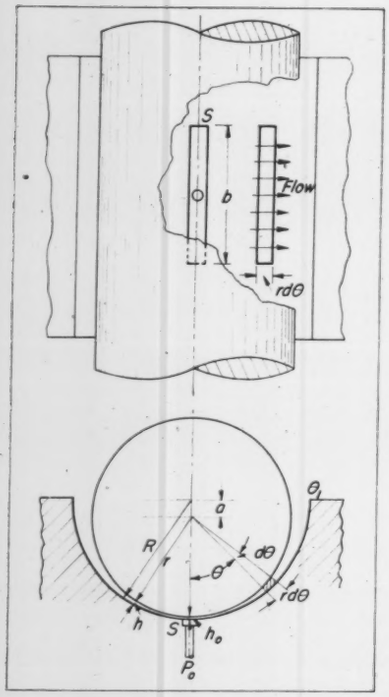

Fig. 15—Left—Shape of passage through which oil flows when journal is floated by hydrostatic oil pressure

available torque is low, this may mean the difference between starting or not starting. Such a device is known as an "oil lift".

Although oil lifts have been used rather extensively their application in many instances is largely a matter of trial and error. This is caused possibly by the fact that rigorous mathematical analysis is somewhat tedious. The form of solution was indicated at least as early as 1925 by Gumbel and Everling* but an exact solution of the equations was not attempted. Instead a numerical and graphical analysis was applied to several selected points resulting in information adequate enough for many design purposes.

With the co-operation of Mr. James Lubkin, assistant in the Mechanical Engineering Dept., Columbia University, the author has developed an explicit solution that needs no numerical or graphical manipulation. It is the purpose of this article to develop the equations as simply as possible and to evaluate the results in the form of curves that can be conveniently employed to predict oil flow and pressure required for oil lifts. Detailed examples will be used to illustrate the application of these equations to practical design problems.

In *Fig.* 15 is illustrated a shaft of radius r being floated in a bearing of radius R by oil pumped through a slot S at pressure P_0, the supply pressure of the pump. Oil flows up the sides until it reaches the relief at some angle where the pressure is approximately atmospheric. It may be assumed that end leakage is negligible, that is, oil flow along the length of the journal is small compared to that up and around the sides of the journal. This condition is closely realized when the slot is shorter than the length of the bearing.

Consider flow up one side through an elemental slot of length $r\,d\theta$ and width b. With laminar conditions the flow through a slot of finite dimensions is given by Equaton 2 in the first article of this series (M.D., June, 1947, Page 112), namely

$$q=\frac{\Delta P\,h^3\,b}{12\,\mu\,l}$$

where q is flow in cu in. per sec, ΔP is pressure difference causing flow, b is width of slot, h is thickness of slot, l is length of slot, and μ is viscosity in reyns (lb-sec per sq in.).

As applied to the elemental slot, ΔP is replaced by dp and l is replaced by $r\,d\theta$. Also, inasmuch as θ increases as the oil film pressure decreases, the equation becomes

$$q_1=-\frac{dp\,h^3\,b}{12\,\mu\,r\,d\theta} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (9)$$

Here the film thickness, h, is not a constant, but depends upon the angular position θ and the eccentricity

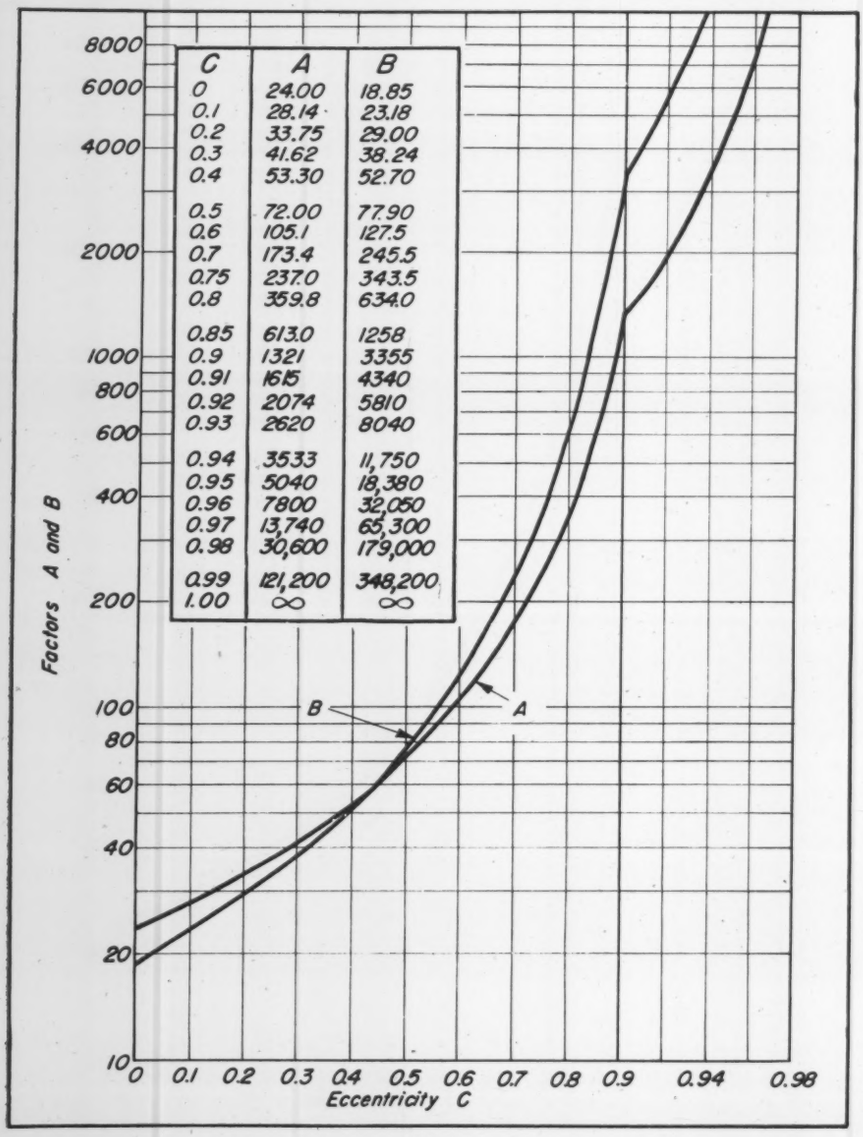

Fig. 16—Left—Tabular and plotted values of the constants in the oil-lift equations for pressure and load-carrying capacity of the bearing

* *Reibung und Schmierung in Maschinenbau* —Gumbel and Everling, Krayn, Berlin, 1925, Pages 49-52.

of the journal in the bearing. When the shaft has settled in the bearing and has made metal-to-metal contact, the eccentricity, which may be denoted by c, is 1. When the shaft and bearing are concentric the eccentricity, c, is zero. The radial clearance built into the bearing can be called mr, where m is a clearance modulus varying from about 0.0005 to roughly 0.003-inch per inch, and r is the radius of the journal. Thus for a journal with radius 5 inches and clearance modulus 0.003-inch per inch the radial clearance in the bearing is 5×0.003 or 0.015-inch.

Referring again to *Fig.* 15, if distance a is small compared to r (this is the usual case) and h is the film thickness at any regular position θ, then

$$h = m\,r - a\cos\theta$$

but

$$a = c\,m\,r$$

therefore

$$h = m\,r(1 - c\cos\theta)$$

Substituting in Equation 9,

$$q_1 = -\frac{dp\,b\,m^3 r^3\,(1-c\cos\theta)^3}{12\,\mu\,r\,d\theta}$$

Separating the variables,

$$dp = \frac{-12\,\mu\,q_1}{b\,m^3 r^2}\,\frac{d\theta}{(1-c\cos\theta)^3}$$

and

$$p = \frac{-12\,\mu\,q_1}{b\,m^3 r^2}\int\frac{d\theta}{(1-c\cos\theta)^3} + D \qquad \ldots\ldots(10)$$

General solution of this equation is

$$p = \frac{-12\,\mu\,q_1}{b\,m^3 r^2}\left[\frac{c\,\sin\theta(4-c^2-3c\,\cos\theta)}{2(1-c^2)^2(1-c\cos\theta)^2} + \frac{2+c^2}{(1-c^2)^{5/2}}\,arc\,\tan\left(\frac{1+c}{\sqrt{1-c^2}}\tan\frac{\theta}{2}\right) + D\right] \ldots(11)$$

The constant of integration can be evaluated by setting $p = 0$ when $\theta = \theta_1$, the angle of relief. When $\theta_1 = 90$ degrees, as in a 180-degree bearing, the constant D becomes

$$D = -\left[\frac{c(4-c^2)}{2(1-c^2)^2} + \frac{2+c^2}{(1-c^2)^{5/2}}\,arc\,\tan\left(\frac{1+c}{\sqrt{1-c^2}}\right)\right]$$

The inlet pressure, P_0, of the oil-lift groove can now be evaluated for the 180-degree bearing by letting $\theta = 0$ in Equation 11, which leads to

$$P_0 = \frac{\mu\,q_1}{b\,m^3 r^2}(B) \qquad \ldots\ldots(12)$$

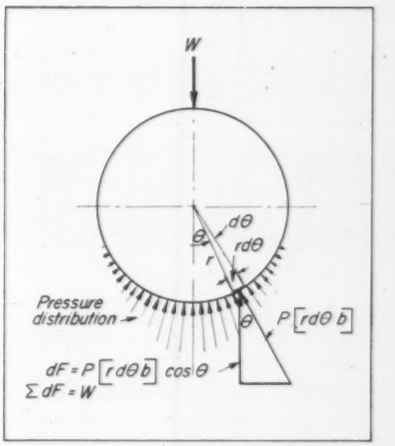

Fig. 17—Load-carrying capacity is summation of vertical components of pressure forces acting on lower surface of journal

where the term (B) is given by the following equation:

$$B = 12\left[\frac{c(4-c^2)}{2(1-c^2)^2} + \frac{2+c^2}{(1-c^2)^{5/2}}\,arc\,\tan\left(\frac{1+c}{\sqrt{1-c^2}}\right)\right]$$

Values of B have been calculated and are listed on *Fig.* 16, which also includes a plot of these points. Excellent agreement is found between these values and those reported by Gumbel and Everling. The significance of the subscript 1 on q is to indicate that q_1 represents the flow

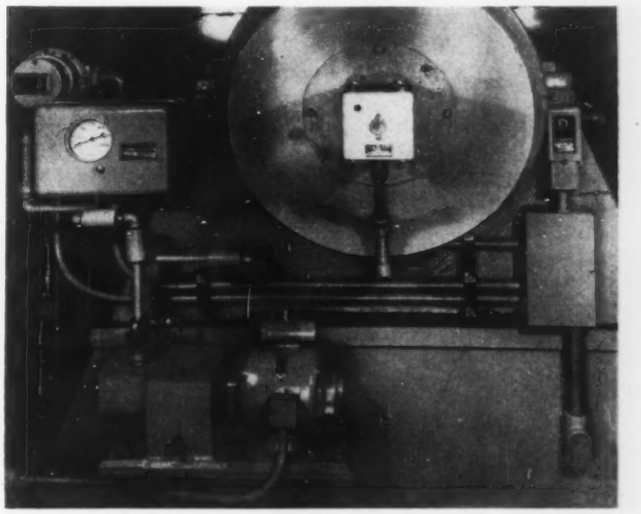

Fig. 18—Above—Large bearing pedestal designed for hydrostatic lubrication. Photo, courtesy General Electric Co.

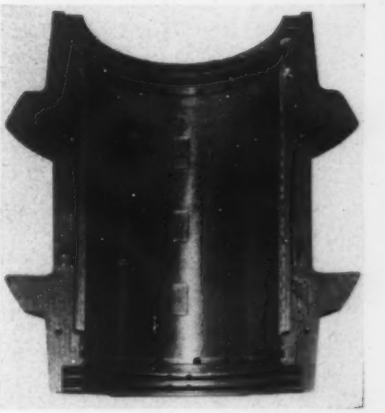

Fig. 19 — Right — High-pressure oil-lift recesses in an 18-in. by 31½-inch journal bearing. Photo, courtesy General Electric Co.

up one side of the bearing only. Because of symmetry the total flow will be twice this value.

To evaluate the load-carrying capacity the pressure distribution must be calculated, *Fig.* 17. At position θ the pressure is p. It acts on area $r\,d\theta\,b$ and produces a force toward the center of the journal. The vertical component of this force, $p\,r\,d\theta\,b\,cos\theta$, will act vertically upward and carry part of the load W. The total load W will be sustained by the summation of all these small vertical forces acting on the lower surface of the journal. Expressed algebraically for the general case this becomes:

$$W=2\int_0^{\theta_1} b\,r\,d\theta\,p\,cos\theta$$

where p is substituted from Equation 11. For the 180-degree bearing with $\theta_1 = 90$ degrees the integration eventually simplifies to the following:

$$W=\frac{\mu\,q_1}{m^3\,r}(A) \qquad (13)$$

where

$$A=12\left[\frac{2+3c-c^3}{(1-c^2)^2}\right] \qquad (14)$$

Numerical values of A are tabulated and plotted on *Fig.* 16. Solving for q_1 from Equation 13,

$$q_1=\frac{1}{(A)}\,\frac{W\,m^3\,r}{\mu} \qquad (15)$$

The expression for minimum film thickness in terms of eccentricity of shaft is, from *Fig.* 15, $h_0 + a = mr$, which may be writen $h_0 = mr - cmr$, or

$$h_o=m\,r(1-c) \qquad (16)$$

Solving for c, the eccentricity,

$$c=1-\frac{h_o}{mr} \qquad (17)$$

Example: A 4.000-in. diameter journal rests in a bearing of diameter 4.012 in. SAE 30 oil at 100F is supplied under pressure through a groove at the lowest point of the bearing. Length of bearing is 6 in., length of groove is 3 in., and load on bearing is 3600 lb. What inlet pressure and oil flow are needed to raise the journal (a) 0.002-in. and (b) 0.004-in.?

Solution: Radial clearance = mr = ½ (4.012 − 4.000) = 0.006-in., hence the clearance modulus is m = 0.006/2 = 0.003-in. per in. and the eccentricity, from Equation 17, is c = 1 − (0.002/0.006) = 0.667. Viscosity for SAE 30 at 100F from the example worked out in Part I of this series (M.D. June, 1947, Page 112), is 152 × 10^{-7} reyns (lb-sec per sq in.).

From *Fig.* 16, for c = 0.667, A will be 140 and B will be 183. Substituting values in Equation 15

$$q_1=\frac{3600\times(0.003)^3\times 2}{140\times 152\times 10^{-7}}$$

q_1=0.091 cu in. per sec (one side) or

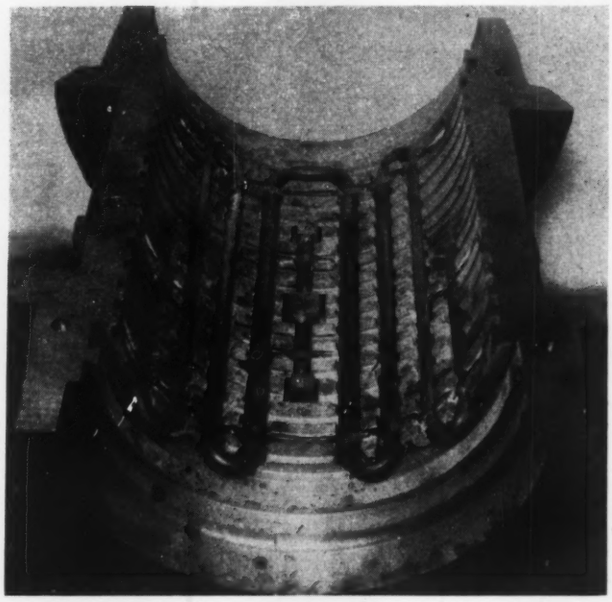

Fig. 20—Above—Bearing shell prior to babbitting, showing high-pressure oil pipe in center and water-cooling coils. Photo, courtesy General Electric Co.

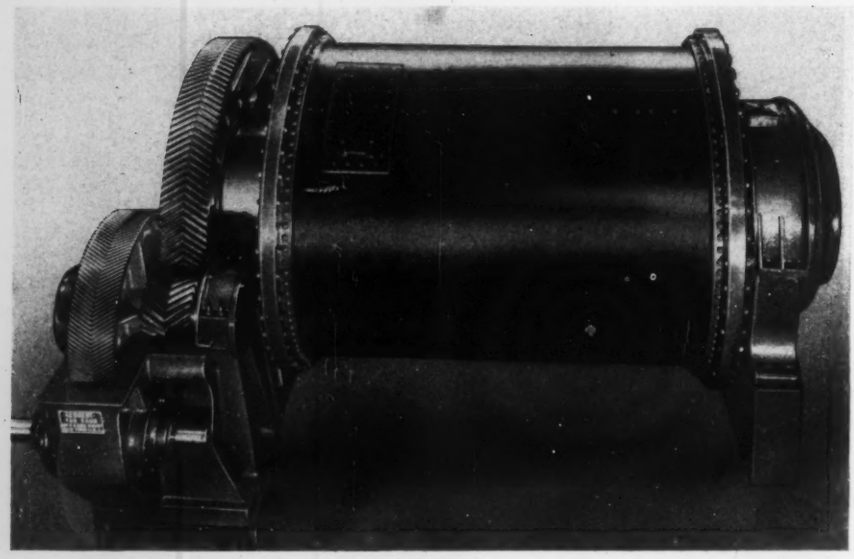

Fig. 21—Left—Main trunnion bearings of ten-foot diameter ball mill employ oil lifts to reduce starting friction. Photo, courtesy Kennedy-Van Saun Mfg. & Eng. Corp.

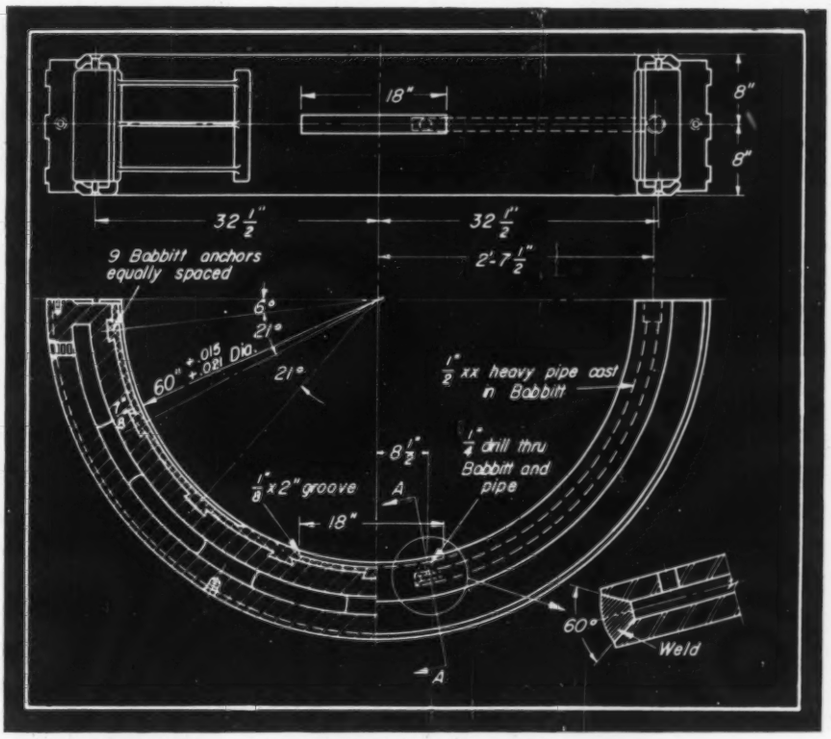

Fig. 22—Detail of main bearing for ball mill, showing arrangement of high-pressure piping for oil lift. Drawing, courtesy Kennedy-Van Saun Mfg. & Eng. Corp.

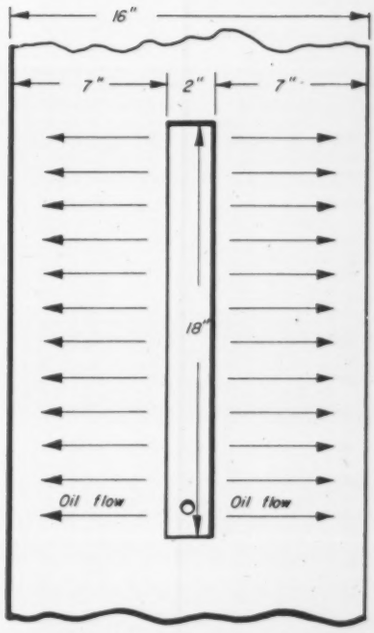

Fig. 23—Above—Developed view of oil lift groove in ball-mill bearing

$$Q=\frac{0.091\times2\times60}{231}=0.0478 \text{ gpm (total)}$$

From Equation 12,

$$P_o=\frac{0.091\times183\times152\times10^{-7}}{3\times2^2\times(0.003)^3}=784 \text{ psi}$$

Repeating the same procedure for $h_0 = 0.004$-in., $c = 0.334$, $A = 44.5$, $B = 42$, $q_1 = 0.2896$-cu in. per sec, $Q = 0.1505$-gpm, and $P_0 = 566$ psi.

Obviously the closer the shaft is to the center of the bearing the smaller the pressure required and the larger the oil flow. Some designers prefer a constant-displacement pump with adequate pressure and volume capacity. Others use high-pressure spur-gear pumps. The pressure capacity of the pump should be greater than that calculated by the foregoing method for the reason that as the shaft begins to lift from the bearing, the initial eccentricity being one, it progressively moves through eccentricities of 0.9, 0.8, 0.7, etc., and in passing through these large eccentricities higher pressures are momentarily needed than for lower values such as 0.6, 0.5, 0.4, etc.

For example, the General Electric Co. has observed that on bearings loaded to about 200 psi average pressure, the oil lift pressure may rise to 1000 psi as the pump comes up to speed. The journal will rise in two or three seconds and then the oil pressure drops back to between 300 and 500 psi. *Fig.* 18 shows a small motor-driven gear pump mounted on the bearing support of a large synchronous condenser. This particular machine was equipped with a pressure gage and relay for interlocking connections with the starting equipment. G. E. recommends that such a pump for their large bearings should be capable of developing for a short time at least 1000 psi with a capacity of 1 to 2 gallons per minute, depending of course on the size of the bearing and other factors already outlined.

Pressure relief valves for a gear pump are also recommended if the relationship between the area of high pressure recess in the bearing and the pressure developed by the pump is such that the shaft does not rise quickly enough and establish a flow of oil. Gear type pumps under these conditions are likely to heat and stick in a few minutes. G. E. practice has been to make the total area of the high-pressure recess in a bearing from 2½ to 5 per cent of the normal projected area (diameter times length) of the bearing, *Fig.* 19. A bearing shell before the babbitt has been cast is shown in *Fig.* 20.

Reduces Starting Friction on Ball Mill

An interesting application using a constant-displacement oil-lift pump has been made by the Kennedy-Van Saun Mfg. & Eng. Corp. On heavy ball-mill type coal pulverizers, some as large as 10 ft diameter by 18 ft long, oil lifts are used to reduce the starting friction. *Fig.* 21 shows the main trunnion bearings in which the cylinder slowly revolves while reducing the coal to pulverized size. The detail of the main bearing of the mill, *Fig.* 22, illustrates the location of the oil lift groove, which is 18 in. long, 2 in. wide and ⅛-in. deep. Oil is supplied to the groove through a ¼-in. hole drilled through the bottom of the groove into a ½-in. pipe cast in the babbitt lining of the bearing. This design has been found to work well with two constant-displacement oil pumps, one for each bearing, delivering 0.528-gpm with the pumps operating at 1750 rpm. A compounded mineral oil is used with viscosity of 3400 saybolt seconds universal at operating temperature of 100F, approximately SAE 70. Load on each bearing is about 138,000 lb.

When a pump is first started, pressure rises to about

920 psi but quickly drops back to roughly 480 psi as soon as the journal lifts. The mill then floats freely and actually begins to move by itself due to nonsymmetrical loading of the grinding balls and coal in the mill barrel. Equations 12 and 13 cannot be effectively applied to this bearing because of its unusual geometry and design. Such a narrow bearing—60 in. wide but only 16 in. long—with an l/d ratio of about ¼ would have considerable end leakage. The groove is also made perpendicular to the axis of the shaft rather than in the parallel position used in the derivation of the oil-lift equation.

Actually the flow conditions are similar to those for flow through a slot as developed in the first article of this series. Neglecting effect of curvature of the film and assuming constant film thickness,

$$Q=\frac{\Delta P\, h^3\, b}{12\,\mu\, l} \qquad (18)$$

The slot through which the oil flows in this case is shown in *Fig.* 23. The following data are known: Q = 0.528-gpm (both sides), q = 1.017 cu in. per sec (one side), l = 7 in., b = 18 in., P = 480 psi, and oil viscosity = 663 centipoises (determined by the conversion method explained in Part I) = 663 × 1.45 × 10^{-7} reyns. Substituting in Equation 18

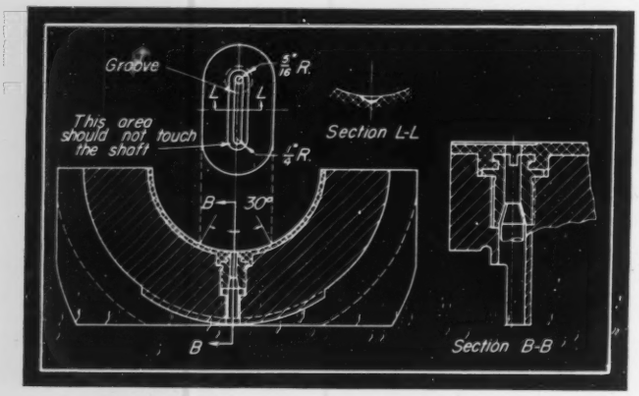

Fig. 24—Detail of a 5-in. by 10-in. bearing with oil lift, showing the proportions of the groove. Drawing, courtesy Westinghouse Electric Corp.

$$1.017=\frac{480\times h^3\times 18}{12\times 663\times 1.45\times 10^{-7}\times 7}$$

From which h^3 = 0.951 × 10^{-6} and h = 0.983 × 10^{-2} or approximately 0.01-in.

Diametral clearance based on mean diameter of bearing and journal is 0.021-in. with radial clearance of 0.01-in. These calculations would indicate that the journal rises under the action of the oil lift and floats concentrically in the middle of the bearing. Although accurate measurements of the lift have not been possible in the field, visual observations indicate that the rise of the journal before the mill is started actually is of this order of magnitude.

An interesting application by the Westinghouse Corp. is found in large synchronous condensers. When the rating of these units exceeds 7500 kva, they are provided with oil lifts, *Fig.* 13. Each bearing is provided with a separate, complete system, mounted as close to the bearing as possible, the purpose being to reduce the starting torque and thus prevent large current and voltage disturbances in the line. An interlocking system of pressure-actuated controls prevents starting the synchronous condenser until the pressure developed by the oil-lift pump reaches a predetermined value adequate to raise the journal. Details of a 5-in. by 10-in. bearing are shown in *Fig.* 24.

For bearings up to 10-in. diameter, Westinghouse has found that a gear pump is satisfactory if it can deliver 0.25-gpm of oil at 1000 psi. At starting, the oil-lift pressure rises to between 1000 and 1500 psi, depending upon the size of the bearing, but quickly settles back to between 700 and 900 psi when the journal has lifted. The amount of journal rise will vary from 0.004 to 0.008-in. depending upon load, clearance and other variables as already outlined.

Separate Pumps Recommended

Best practice in heavy rotating equipment indicates using a separate pump for each bearing. If this is not done and two or more bearings are connected to the same pressure source, the first journal to rise might well drain the high-pressure oil from the rest of the system, resulting in only partial lifting of the remaining journals.

It is possible to use only one pump if flow to each of the bearings is restricted in some manner so that a drop in pressure in any one of the branches will not prevent the pump from building up the required pressure in the other branches of the system. Fixed orifices, or adjustable orifices in the form of needle valves, perform satisfactorily. In some applications, multicylinder reciprocating pumps have been used, with each of the bearings connected to a separate cyinder. Thus the discharge from each individual cylinder has to pass through the single bearing to which it is connected, instead of most of the pumped oil discharging through that particular bearing which is the first to have its journal lift.

Good practice also indicates the use of a check valve in the discharge line of the high-pressure pump so that, when the journal has been started and is rotating, the hydrodynamic oil film pressure that is built up will not cause reverse flow with oil being forced back into the idle pump. With no check valve the pump might actually be driven in reverse by oil from the bearing. In addition oil being drained away from the active load-carrying film would greatly reduce the capacity of the bearing.

With a reasonably exact solution to the oil-lift problem now available it should be possible for the machine designer to proceed quickly and confidently to an evaluation of the factors involved. Pump pressure and volume characteristics can be predicted with good accuracy for almost any type of oil-lift problem. The equations in this article were specifically developed for the 180-degree bearing but when used judiciously they can be applied to partial bearings as well.

The design of step bearings and other load-carrying devices based on the principles of hydrostatic lubrication will be discussed and illustrated in the next article of this series.

Designing Hydraulic Servos

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Chicago

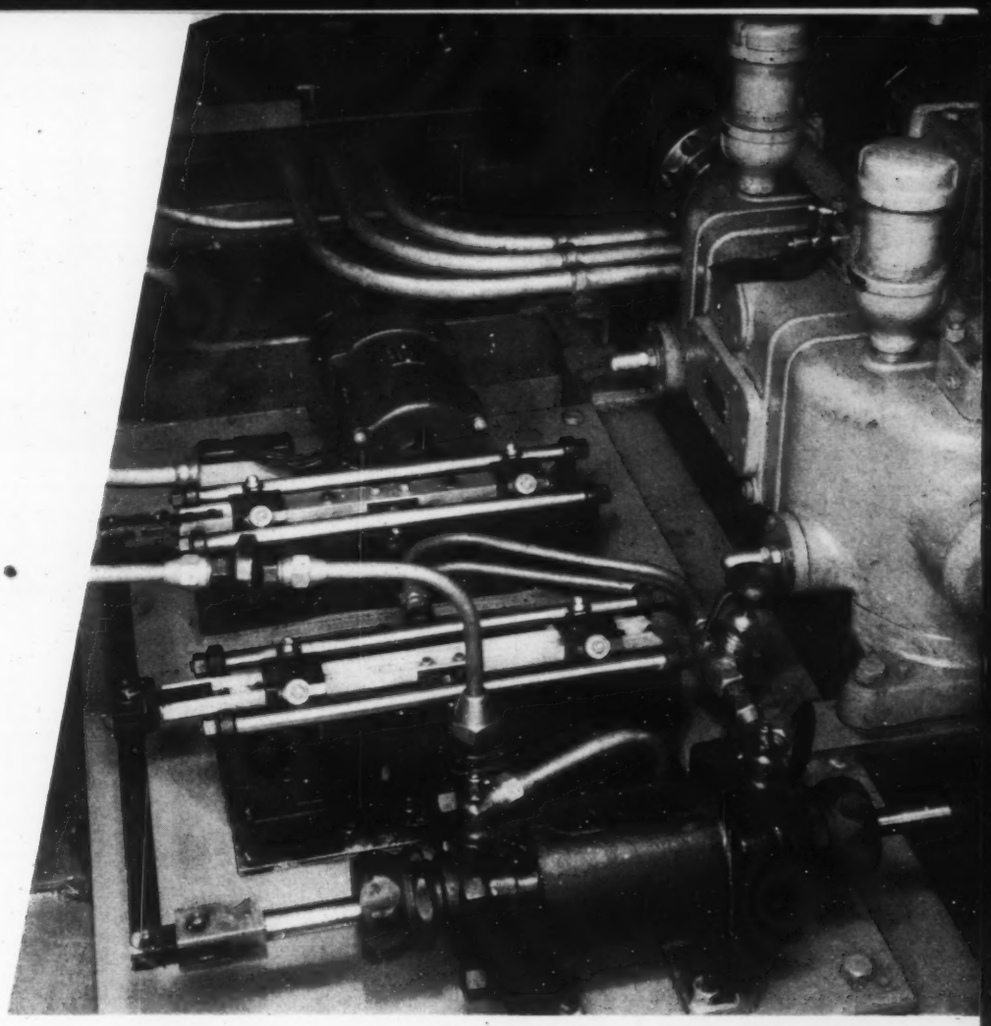


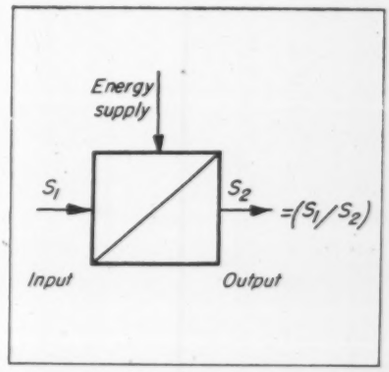
Fig. 1 — Above — Electrohydraulic transmission of a motion to a cradle. Same device is used for operating charging machines, hoists, etc.

THE LAST few decades have witnessed a general trend in the development of devices to automatically control the power which is now at the disposal of man and to supervise and adjust such controls over greater distances. This article will discuss some of the basic components of control devices, such as illustrated in *Fig.* 1, which for a given input produce automatically a corresponding output.

Controllers of this type, using an additional energy supply to enforce a definite relationship between input and output, are called servomechanisms. They differ from other automatic controllers only insofar as the process usually involves inertia, torque or friction, and input as well as output are of the same variable, that is, a motion or stroke or a corresponding angular displacement.

IN THIS ARTICLE, hydraulic servos are analyzed and developed from basic translators. The system frees the mind from much detail and is particularly useful when designing new servo units. Fundamentals of the system and method of cataloging were discussed in the article, "A New Approach to Design" in the June issue

Fig. 2—Below—Simple symbols obviate sketches, facilitating design



To make it possible to represent a translator of the input s_1 into an output s_2 without the need of sketches, the symbol (s_1/s_2) will be used. Replacing *Fig.* 2, the symbol is read: "s_1 over s_2 translator." The classical example of such a device is still used in many installations. Shown in *Figs.* 3 and 4, it consists of a lever *ABC* one end of which moves an amount equal to s_1 and the other end the amount s_2. The ends move in opposite directions.

Point *B* of this lever is connected to a four-way valve which admits or releases a fluid medium (oil, water, steam or air) to or from both sides

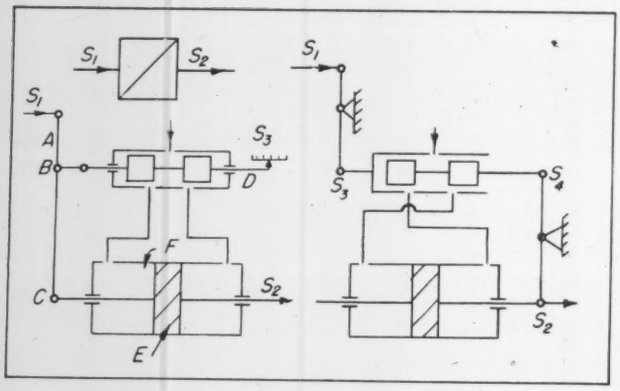
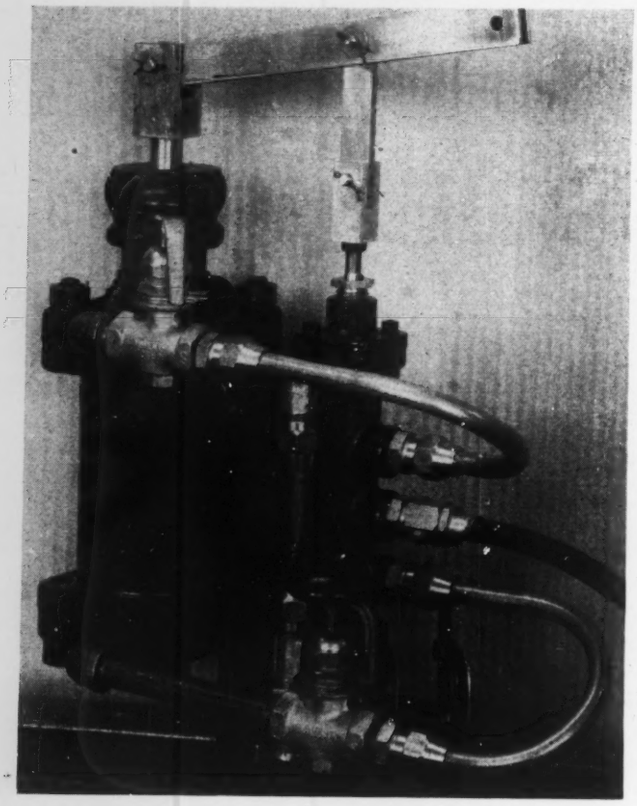


Fig. 3—Lever servo with four-way valve attached to fulcrum for energy supply

Fig. 4—Hydraulic servo of the type illustrated in Fig. 3



of double-acting piston E inside of cylinder F. The arrangement is such that a displacement of s_1 to the right moves the pilot valve B in the same direction and thereby admits fluid pressure to the right-hand side of piston E. The resulting travel of piston E to the left cuts off the energy supply controlled by the displacement of the pilot by reducing its movement s_3 to zero. As a result we finally have

$$s_1 = C \cdot s_2 \text{ and } s_3 = 0$$

Because the whole story of servomechanisms is contained in this example, it may be well to study the device a little further. What are its basic components? First of all, the transmitter has its input s_1. Second, the "receiver" has an output s_2 which is to be proportional to s_1.

In order to establish this relationship a device comparing s_1 to s_2 is needed. This is basically a "summarizing" device in which a relay or amplifier is operated whenever s_1 is not equal to $C \cdot s_2$ or, more exactly whenever s_3 is greater than the neutral or dead zone of the amplifier. Investigating the relationship between s_2 and the rate of travel of the "power unit" which integrates this rate to produce s_2, it becomes apparent that various characteristics are possible.

In *Fig. 5a* is shown an amplifier with a dead zone and a single speed in each direction. By reducing the dead zone to zero a continuously reversing power unit, *Fig. 5b*, is obtained. In *Fig. 5c* the speed of the motor increases by steps for various values of s_2. Increasing the number of steps to infinity, the curves in *Fig. 5d* are obtained with and without a dead zone.

The foregoing are the most typical amplifier characteristics and, as nothing is said about design details or their construction, they can represent electric, hydraulic or pneumatic power units or motors. The particular choice of design depends on:

1. Specifications of accuracy
2. Time constants (inertia of the load)
3. Available power supply
4. Space requirements
5. Economic considerations
6. Service, facilities
7. Life expectancy
8. Stability.

Power unit EF shown in *Fig. 3* is a double-action piston which moves at a rate controlled by the amplifier relay and integrates this rate into a stroke

$$s_2 = c \int \frac{ds_2}{dt} dt$$

As the lever ABC is basically a summarizing device with the positive input s_1, the negative input s_2 and the

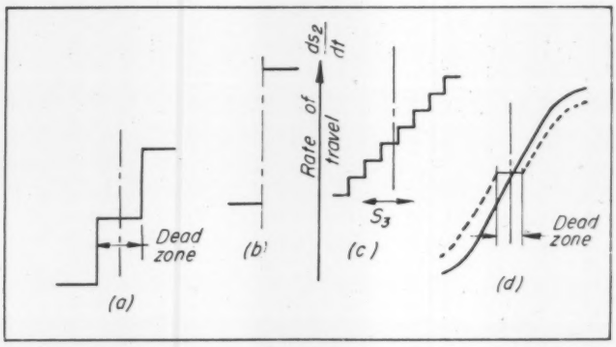
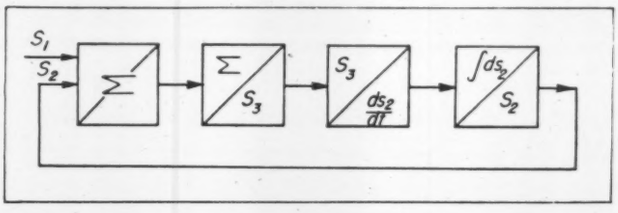


Fig. 5—Characteristics of amplifiers with dead zone and single speed in each direction shown at (a), without dead zone at (b), step speed increase at (c), and variable speed increase at (d)

Fig. 6—Below—Block diagram for a feed-back system



final relay motion $s_3 = 0$ it can be replaced with any other device having this characteristic. This device may be represented by a box symbol, as shown in *Fig.* 2, with s_1 and $-s_2$ as input, the Σ sign and the output $(s_1 - s_2)$.

In order to indicate a series arrangement for several translators, a plus sign is used. In the representation the output of the preceding translator must be the input of the following translator, the fraction sign separating the input from the output.

Referring to *Fig.* 6, the following translator boxes in series are obtained:

1. A translator which changes s_1 into s_3, this translator to be represented by (s_1/s_3).
2. A translator which changes the displacement of the relay s_3 into a corresponding rate of the cylinder s_2. This translator is therefore represented by

$$\left(s_3 \Big/ \frac{ds_2}{dt}\right)$$

3. A translator which, with the input ds_2/dt, produces an output s_2.
4. A summarizing device which summarizes the strokes s_1 and s_2 with the additional condition to be fulfilled that the sum of these two strokes should produce a stroke s_3, which is to become equal to zero. The whole device therefore can be written as the sum of all the translators, which indicates the series arrangement:

$$(s_1/s_3)+\left(s_3 \Big/ \frac{ds_2}{dt}\right)+\left(\int \frac{ds_2}{dt}\,dt/s_2\right)$$

Furthermore balance is obtained when

$$\Sigma(s_2+s_1)=s_3=0$$

or, in a different form, starting with the summarizing device and ending with the integrator, we can write it as a translator chain in the following equation:

$$\Sigma(s_1+s_2)+(\Sigma/s_3)+\left(s_3 \Big/ \frac{ds_2}{dt}\right)+\left(\int \frac{ds_2}{dt}\,dt/s_3\right)$$

$$s_2 \equiv s_2$$

The equation, $s_2 \equiv s_2$, is to indicate that s_2 in the feedback loop at the end of the chain is equal to the s_2 at the beginning of the chain where the variable s_2 is summarized with s_1.

Advantage of the diagram, *Fig.* 6, is that it establishes

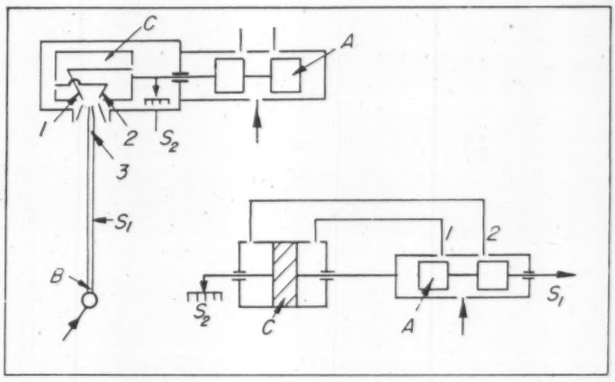
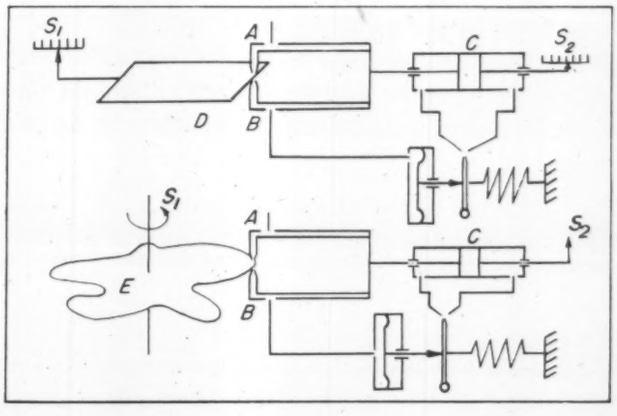


Fig. 7—Multiple servos. Jet on the left is not affected by unbalance or friction of the pilot valve

Fig. 8—Opposing nozzles and pressure regulator keep position of interceptor blade or cam in desired position



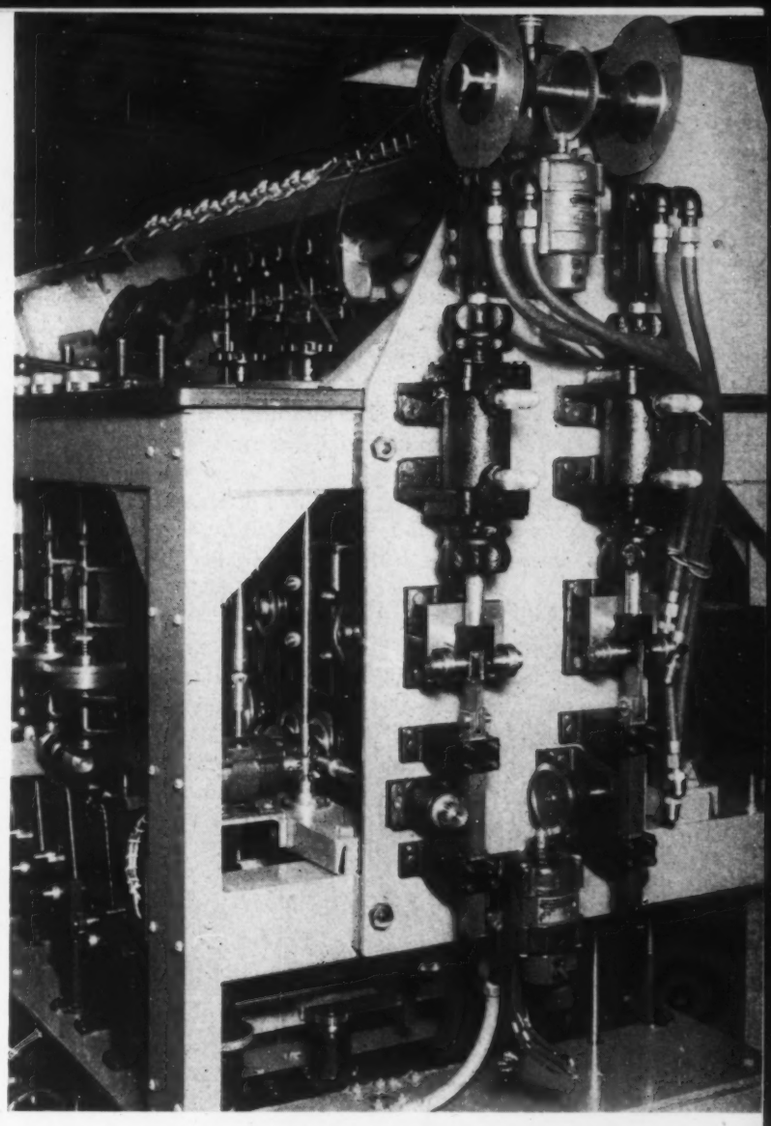


Fig. 9—Pneumatic transmission of a cam contour into a calculating device. This same system, shown diagrammatically in Fig. 8, can be used for contour machining or program control of process machinery

the concept of certain translations and frees them from the confusing details of design. It also permits the functional description of a circuit without the need of drawing block diagrams. It follows, therefore, that other servos can be developed easily by substituting equivalent translators in the chain.

An "equivalent translator" is defined as a translator with the same input and output variable and, in particular, as one in which the input and the output variables are of a desired magnitude. First, summarizing devices will be investigated. In *Fig.* 3 is illustrated the "whiffle tree"; its equivalent is a differential gear (including planetaries).

In the right-hand sketch, *Fig.* 3, the summarizer is of the follow-up type; i.e., a relative displacement of the relay to its center zone is reduced to 0 by deducting s_3 from s_4. These are mechanical summarizing devices. Obviously such devices are not limited to mechanical variables. Any servo (s_1/s_2) can be considered as a chain of the nature $(s_1/\text{variable}) + (\text{variable}/s_2)$ in which *any one* variable or a multitude of variables can be introduced as intermediate parameters.

Thus, if it is found more convenient to summarize or integrate other variables than strokes or rates of travel, it becomes necessary to translate the input s_1 into those most convenient for this operation and then to retranslate the result back into the desired output s_2. There is no limitation in the choice of the intermediate parameters and, in particular, electrical variables like voltage, current, phase angle and frequency can be used. In this article, however, discussion will be confined to a few hydraulic servos or follow-up devices.

The device shown in *Fig.* 7 is used to produce a stroke s_2 of a pilot valve *A* which is directly proportional to the displacement s_1 of the jet pipe *B*. To accomplish this the two receiving nozzles 1 and 2 in front of the jet nozzle 3 are crosswise connected to a double-acting piston *C*. A displacement of the jet nozzle produces a differential pressure between 1 and 2, causing piston *C* to move until the center between 1 and 2 coincides again with the jet-pipe.

Advantage of this system is that the connection between *C* and *B* is produced by a hydraulic jet which prevents any forces acting on *A* from being transmitted to *B*. The summarizing is accomplished by a relative displacement of 3, 1 and 2. If $\Sigma(s_1 + s_2) = s_3$ becomes zero, using a pilot valve is also shown in *Fig.* 7.

The same idea is carried further in the design in *Fig.* 8. A pair of opposing nozzles is separated by a vane which, however, does not touch either of them. Air at constant pressure is supplied through *A*, and the velocity head of this flow is measured by nozzle *B*. A constant-pressure regulator is connected to a double-acting cylinder *C* in such a way that the relative position of the intercepting edge and of the nozzles remains constant,

$$\Sigma(s_1+s_2)=s_3=\text{constant}$$

As a result, the piston in cylinder *C* follows the edge *D* of the interceptor blade only by contact with the air stream. A cam *E* as shown, can be substituted for the interceptor. These cams are not subject to wear and can be cut out of thin stock or even paper. The accuracy of the follow-up is better than 1/1000-inch and the output of power is practically unlimited. In *Fig.* 9 is illustrated an application of such a servo.

If this scheme is to be used for rotary motion, the interceptor blade is changed to a design as indicated in *Fig.* 10. No matter where the motor position may be, i.e., the position of a selsyn, or a synchro, the cam *A* will always establish its correct position.

By using a rotary type hydraulic motor there is no limit in angular rotation. The force necessary to rotate the interceptor blade *A* is negligible and hardly greater than the friction of the selsyn or synchro bearings. Thus this scheme lends itself particularly for duplicating with greater accuracy the positions of selsyns.

In *Fig.* 11 a two-stage servo operated from selsyns is shown. The principle applied is the same as before. Movement s_3 controls the displacement of a hydraulic jet pipe and establishes the relation between s_1 and s_2. Movement of s_2, with ample power, is used to vary the oil delivery of a positive displacement oil pump which is connected to an oil motor so that ds_5/dt will be directly proportional to s_4.

In a later article pneumatic and electric follow-up devices will be treated and it will be shown that their basic design is the same as that of the devices in this article.

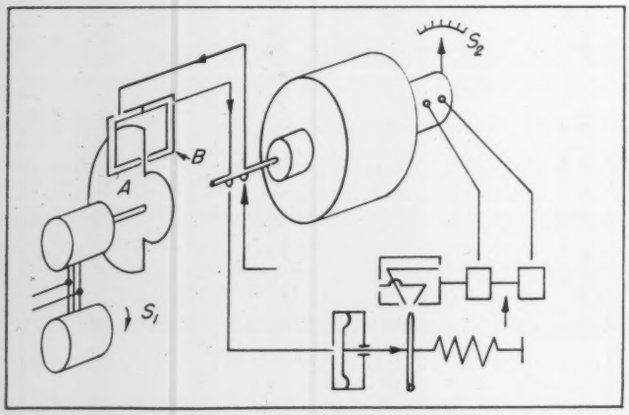
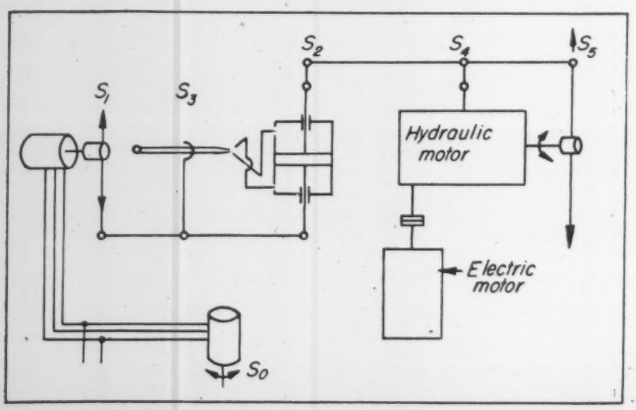


Fig. 10—Opposing-nozzle system to maintain correct position of a selsyn or synchro

Fig. 11—Two-stage servo operated from selsyns. Application of this system is shown in Fig. 1



CORRECTION: In the June issue, the article by Mr. Eck entitled, "D-C Relays" contained a regrettable error in that the illustrations for *Figs.* 5 and 7 were transposed. Our sincere apologies to the author and readers.—Ed.

Automatic Inspection System

. . . its mechanical gaging contacts handle only minute currents which control thyratron amplifier grids

By Charles W. Warren
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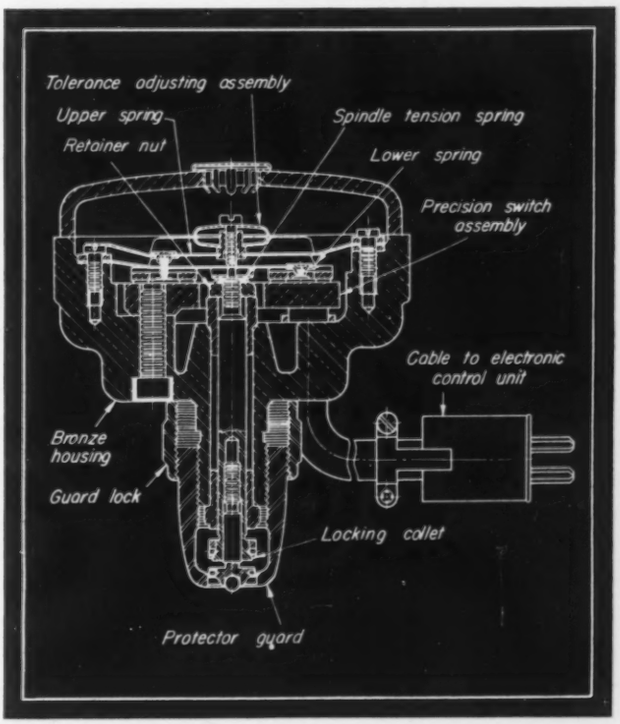
Fig. 1—Above—Principal units of inspection system are: Gage head (foreground), electronic gage control (immediately behind gage head), and counter (rear)

IN DESIGNING automatic inspection equipment for universal application, the system should be flexible enough to permit its efficient use for checking and sorting a wide variety of part shapes and, furthermore, should lend itself readily to integral incorporation into parts-producing machines or production lines. Such a system is the Limitron, *Fig.* 1, which comprises three separate but co-ordinated basic units, namely: (1) A gage head, (2) an electronic control, and (3) a classifier or sorter. As will be apparent, this three-component system adequately meets the requirements already stated. However, other problems of a more intimate nature are involved.

For example, purely electronic means for providing high amplifications in a gaging system suffer from long-time stability, i.e., the system is dependent on tube warm-up, line-voltage variations, etc. Thus, operator dependence is relied upon to keep the equipment "zeroed", especially during the initial turn-on period. Conventional electromechanical devices for gaging do not suffer this stability disadvantage. However, if they are made sufficiently sensitive to measure small increments (less than 0.0001-inch), the necessary contacts or switching elements are not capable of doing appreciable electrical work without serious damage, shortening of life span, drift from heat, etc.

Difficulties experienced with both the electronic and conventional electromechanical means are overcome by a combination unit employing an extremely sensitive mechanical gage the contacts of which are required to con-

Fig. 2—Below—Section through gage head shows design



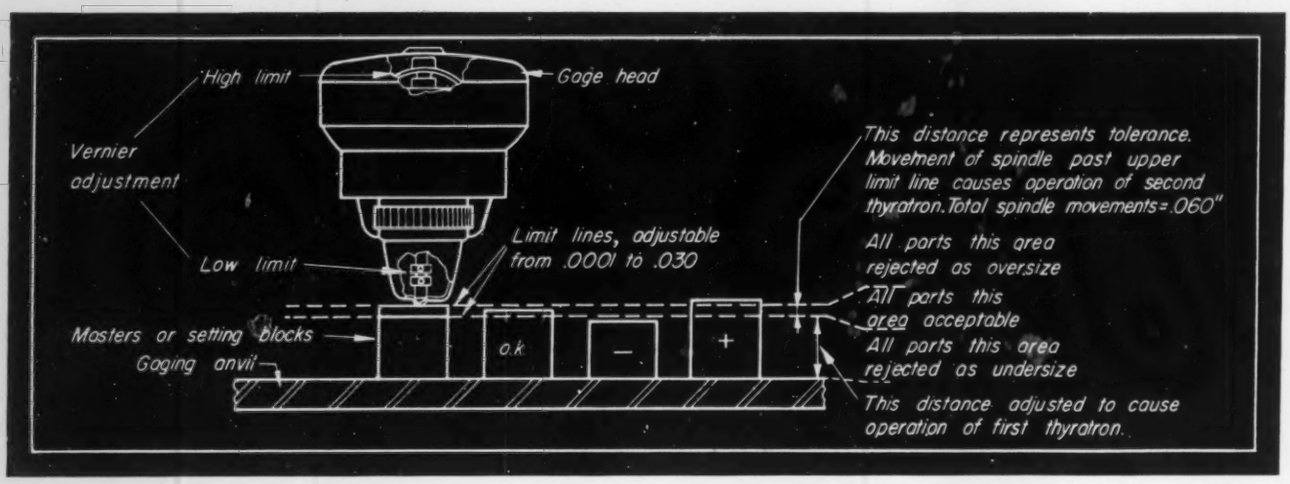


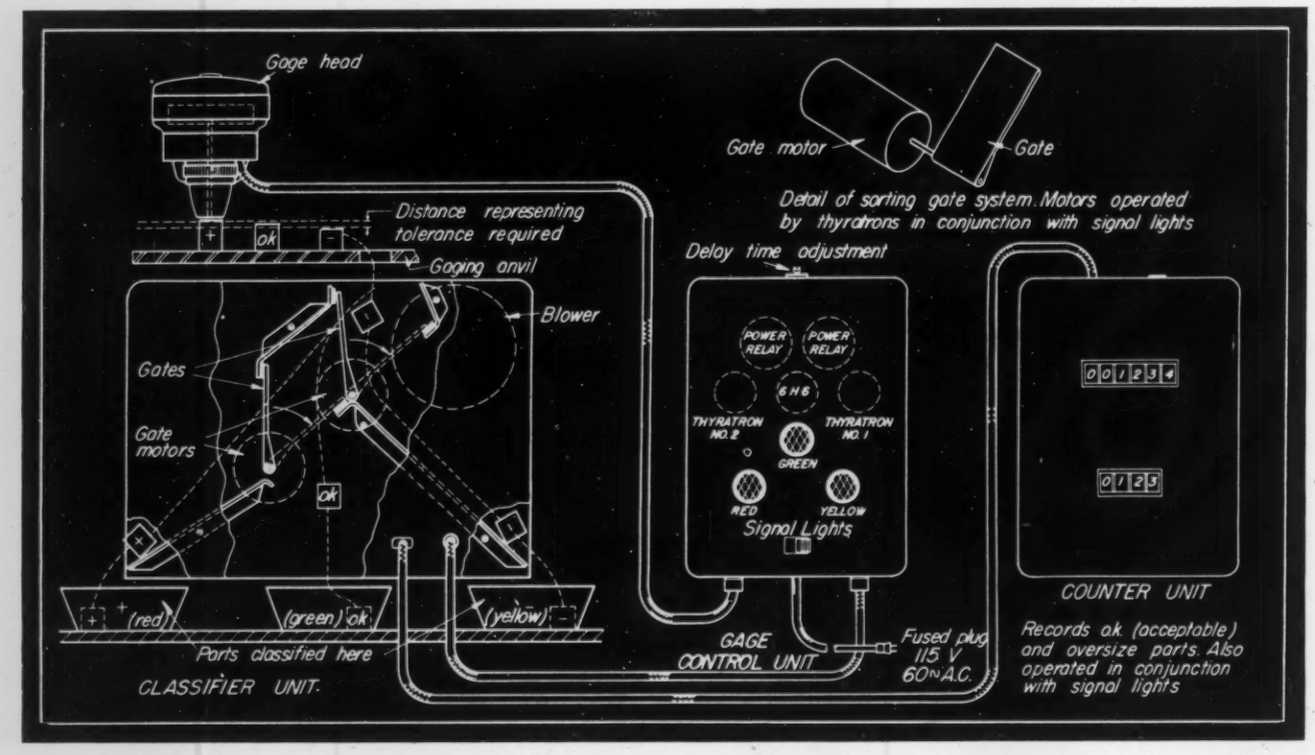
Fig. 3—Principles of gaging, showing how two limit lines are positioned to segregate parts three ways

trol only the grid circuits of thyratron tubes acting as power amplifiers, *Fig.* 2. Actual electrical power handled by the contact mechanism is approximately 0.03-watt, while the power required for the entire equipment comprising sorting, signaling, counting, etc., is in the neighborhood of 150 watts. Heating, arcing, drift and wear of contact points thus is reduced by a factor of 5000 through the use of the power amplifier.

An additional feature of this electronic amplifier is control of the delay or lag time of the sorting means. When the work part has been presented to the gage head, measurement takes place by displacement of the gage-head spindle. The gage-head contacts set the sorting gates, deflectors, etc., to pass the part into the category decided by the head. After the part leaves the gage position the gage spindle returns to its normal position in preparation for receiving the next work part, but the gates or sorters must retain their setting for a period of time long enough for the part to gravitate through the system into the proper category. This delay system is provided by a simple and accurate condenser charge arrangement which operates to maintain the thyratrons in their energized condition for an adjustable period of time varying from zero to a maximum of two seconds after the work part has left the gage spindle.

Reference to *Fig.* 3 will show the principles of limit gaging provided by this system. The drawing shows how the two limit lines may be positioned in order to segregate the work parts three ways. The gage head is roughly positioned to the low-limit master block on its mounting stand, and then the vernier or fine adjustment is made to cause the first pair of contacts in the gage head to close

Fig. 4—Below—Diagrammatic layout of typical system, showing how classifier unit sorts parts three ways



at this point. This adjustment is easily made to the accuracy of the blocks or masters used. Then the upper contacts are adjusted to close by using masters or gage blocks corresponding to the upper acceptable limit of the part being gaged. It is important to note that both of these simple adjustments, once made, are completely covered and out of the reach of the operator. No further settings by the operator are encouraged nor can they be accidentally disturbed.

At this point the electronic gage control takes over, *Fig.* 4. As has been noted, the contacts in the head are required to control only the grid circuits of the thyratrons, the electrical work being performed by the relays in the anode circuits. Much work has been performed on the selection of a suitable relay for long dependable performance and the unit finally chosen evolved as a plug-in type which may be expected to give upward of 10 million operations.

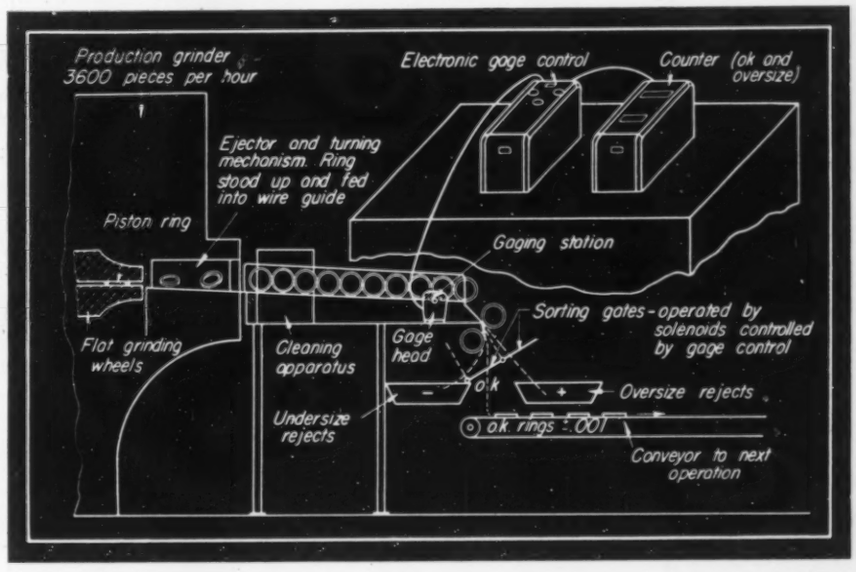


Fig. 5—Gaging system applied as an automatic piston ring sorter

Since the relays, in the aforementioned control unit, supply the control function for the signal lights, the next and last of the three basic package units comprising the system is the classifier. This device is a small sorting mechanism operating electrically to shunt the gaged parts into three basic categories, i.e., undersize, acceptable and oversize. Since the control function is already provided, it is only necessary to provide the operating means from this function to work the flippers or gates according to the category in which the work part is to be placed. Early models of this equipment used conventional solenoids with links and pivot arms to transfer the straight-line motion of the solenoid to the rotary motion required by the gate. While this was a satisfactory method, it suffered from the following two distinct disadvantages:

1. Rapid wear and consequent noisy operation of the link mechanism. While solenoids are capable of reliable operation it was found that several million cycles produced definite deterioration of the system.
2. Torque curve of the solenoid is incorrect for this application. In any solenoid the pull is minimum at the start of the stroke increasing to maximum near the end of the stroke. This is distinctly opposite to the desired gate action as it gives sluggish start with noisy, wear-producing sudden stops.

With these limitations in mind, a special torque motor was developed the characteristics of which are perfectly suited to the requirements. Since the rotor shaft motion is correct, the gate is fastened directly on the ball bearing shaft of the motor. Further, it was possible to arrange for the maximum torque position of the assembly to take place at the beginning of the stroke with the minimum torque at the end. Thus the gate motion is started rapidly and eased into its stop. Use of alnico rotors eliminated brushes so that the life of the sorting mechanism is practically limitless.

Further requirements of the sorting mechanism will be evident upon examination, such as the inclusion of a small air-circulating unit to direct heat away from the gage head. Since the gaging anvil and head usually are mounted directly on or in close proximity to the sorting device, this refinement is an important contribution to the stability of the equipment related to drift from the warm-up period. Covering of the entire inner passageway with replaceable plastic pads insures delicate handling of the most highly finished parts. It is impossible for damage to occur to work parts in the classifier unit since they cannot make contact with any metallic objects.

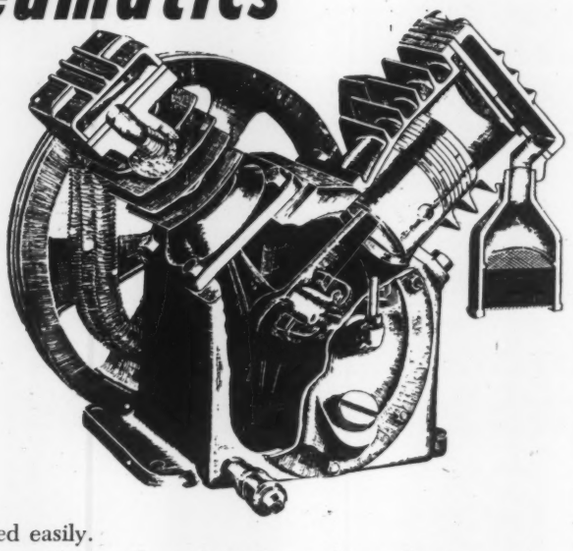
An additional feature of the classifier worth noting is that the design of the gating system is such that it is impossible to pass work into the good or acceptable category without operation of the gage head. Thus, in the event of operator mistake or other circumstance, all parts that might enter the chute without going through the gage will be rejected into the undersize compartment.

It will be apparent that this gaging system can be built-in to many different types of production lines. The schematic drawing, *Fig.* 5, provides an example. The machine depicted provides automatic checking of the thickness of piston rings and no labor other than supervision of the gage is involved. The apparatus has been designed to be fed by the ejector of the grinder. As the rings enter the guide rack, they are fed through a cleaning bath and then air dried. Next they pass a Limitron gage head which measures the thickness of the web and automatically sets the sorting gates to either reject or accept the ring. If it is acceptable, the gates are so positioned to drop the ring on a conveyor belt which moves it to the packaging department. If rejected, it is dropped into either an undersize or oversize container. Oversize rings are fed back into the machine for a second pass and are largely reclaimed while undersize rejects are either scrapped or classified for smaller size pieces.

Designing for Pneumatics

By James L. Dooley
Consulting Engineer
Venice, Calif.

Part IV–Control Uses



CONTROL systems frequently use power boost to utilize a small force or movement from a sensing element to actuate or position a larger force or movement to do the controlling. This power boost may be manual, mechanical, hydraulic, electric, or pneumatic. There are numerous characteristics of compressed air, however, that make it particularly desirable for control work and especially for power boost. These are as follows:

1. It is generally available or easily obtainable in the quantities needed for control.
2. All harmful water, oil mist, and foreign particles can be removed easily.
3. It is nontoxic and can be exhausted anywhere.
4. Response is fast. Unless the distances involved are quite long, the time lag between sensing a change and actually accomplishing it is no greater than with an electrical system. Too, if the load to be handled is quite large, the response lag with a pneumatic system is frequently less than with any other. The original pressure wave travels with the speed of sound in the air (about 1120 feet per second at normal temperature). An example of the reaction time required to transmit a sizable amount

Fig. 32—Reaction time of pneumatic brake system with 60 feet of ⅝-inch O.D. tubing between valve and drums. Displacement in brakes is 50 cu in. at 170 psi. Brake valve used in this system is shown in Fig. 35

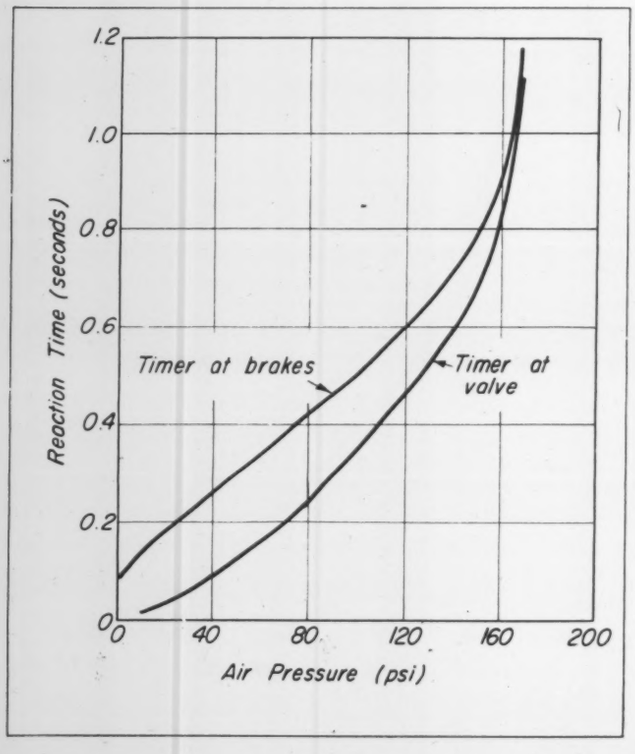
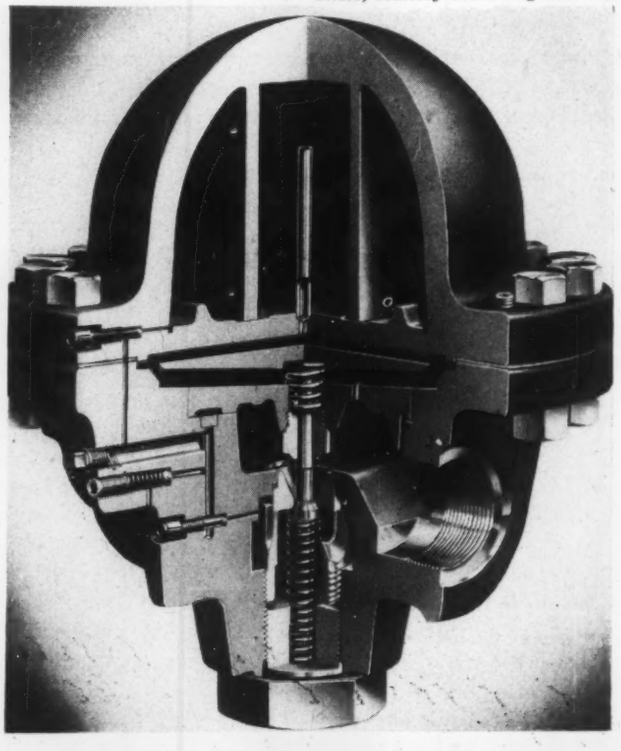


Fig. 33 — Pressure-reducing valve using air-loaded diaphragm. Upper dome is charged with air at desired control pressure and valve is arranged to maintain downstream pressure equal to this charge

Photo, courtesy Grove Regulator Co.



of energy is shown in *Fig.* 32. In this case 660 foot pounds of work has been accomplished at a distance of 60 feet in less than a second after initiation.

5. Within reasonable horizontal and vertical distances, atmospheric air provides an unlimited supply or dump reservoir at a uniform pressure. This is extremely desirable when the two legs of a balanced system are widely separated. Even though the two identical orifices are not together the same air flow can still be expected in each leg since both exhaust against the same atmospheric back pressure. Although the actual atmospheric pressure (barometer) may vary with time, the rate of change is low so it generally offers no problem.

6. An absolute zero pressure reference can be easily obtained with an aneroid bellows.

7. There is no pressure variation between the two ends of a static line—say a long small line with a pressure gage at one end—regardless of temperature. With any fluid in use today a line tends to plug at low temperatures and give a false indication.

8. By arranging the displacement of the piston or diaphragm and the volume of the attached pneumatic system about any equivalent spring rate desired can be obtained. In *Fig.* 33 is a pressure-reducing valve which uses an air spring (in the dome) to get a low spring rate. By using high air pressures behind the piston with communication to adequate receiver capacity, high forces are obtainable that are almost constant with large piston travel. This cannot be accomplished with any mechanical spring.

9. A pressure-change multiplication can be obtained by using two orifices in series. This is a very simple form of pneumatic power boost and *Fig.* 34 shows an air compressor pressure regulator so designed to add cylinder clearance in five steps to unload the machine. The upper diaphragm varies the area of the orifice (pilot control valve), allowing variable flow into the control-pressure chamber which has a fixed orifice open to exhaust. A small increase in pressure lifts the upper diaphragm and valve causing a large increase in pressure in the control chamber. This pressure acts on specially constructed three-way valves to apply or remove air on the diaphragm-operated valves between the cylinder proper and the clearance chamber of the air compressor. In this particular regulator, the control range may be adjusted between 100 and 103 psi which causes as much as 70 psi variation in the pressure chamber or a control multiplication of 23 to 1.

Control with Orifices: In all pneumatic work and especially in control work the flow of compressed air through small orifices finds such extensive application that it should be given special consideration. With compressed air the mass-flow through an orifice is influenced by the downstream pressure when the pressure drop across the orifice or nozzle is so low that the velocity at the orifice throat is subsonic. At expansion ratios, through the orifice, high enough to cause sonic velocities or higher at the throat, the mass-flow is independent of the downstream pressure. This critical point occurs when the downstream absolute pressure is 53 per cent of the upstream absolute pressure and under these conditions the throat velocity is equal to the velocity of sound in that air.

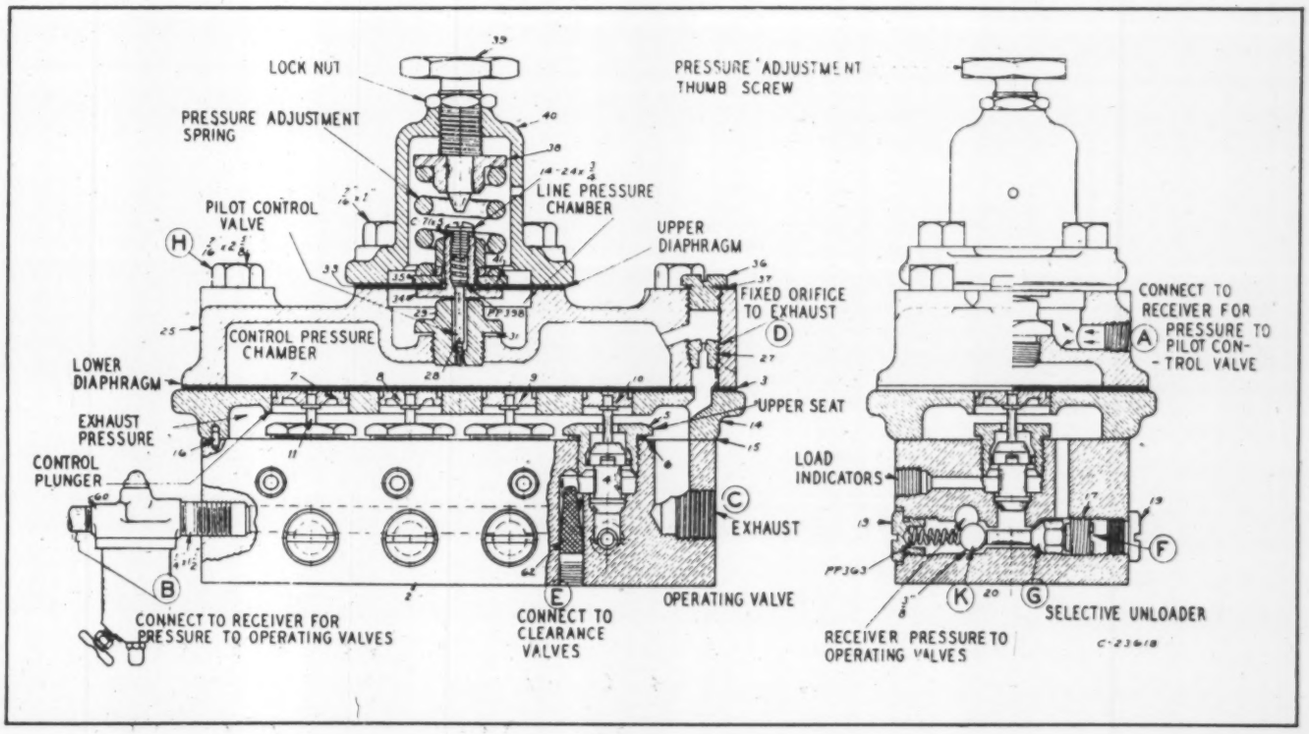
Below the critical flow conditions where $P_2 > 0.53P_1$, the following flow equation applies:

$$W = \frac{0.595\, C\, D^2 P_2}{T_1 \sqrt{\frac{n-1}{n}}} \sqrt{\frac{P_1}{P_2}} \sqrt{\left(\frac{P_1}{P_2}\right)^{\frac{n-1}{n}} \left[\left(\frac{P_1}{P_2}\right)^{\frac{n-1}{n}} - 1\right]} \quad \ldots\ldots\ldots (15)$$

where W = weight of air flowing in pounds per minute;

Fig. 34—Pressure regulator for an air compressor utilizing two orifices in series to obtain pneumatic power boost

Photo, courtesy Ingersoll-Rand Co.



C = coefficient of discharge (about 0.65 for a sharp-edged hole and 0.96 to 0.99 for a well-rounded orifice); D = diameter of throat in inches; P_1 = upstream pressure in psi absolute; P_2 = downstream pressure in psi absolute; T_1 = upstream temperature in degrees Rankine; w = air density on upstream side of nozzle in pounds per cu ft; n = ratio of specific heats of air at constant pressure to constant volume; (n = 1.406 for dry air and 1.3947 for 36 per cent relative humidity air at 68 F).

Above the critical flow conditions where $P_2 < 0.53P_1$ the flow is independent of the downstream pressure so the equation becomes:

$$W = 0.5303\frac{a\,c\,P_1}{\sqrt{T_1}} \qquad (16)$$

where a = area of orifice in square inches.

High pressures (above 300 psi) are almost never used for control work where accuracy or sensitivity are paramount because the loads are high even though the com-

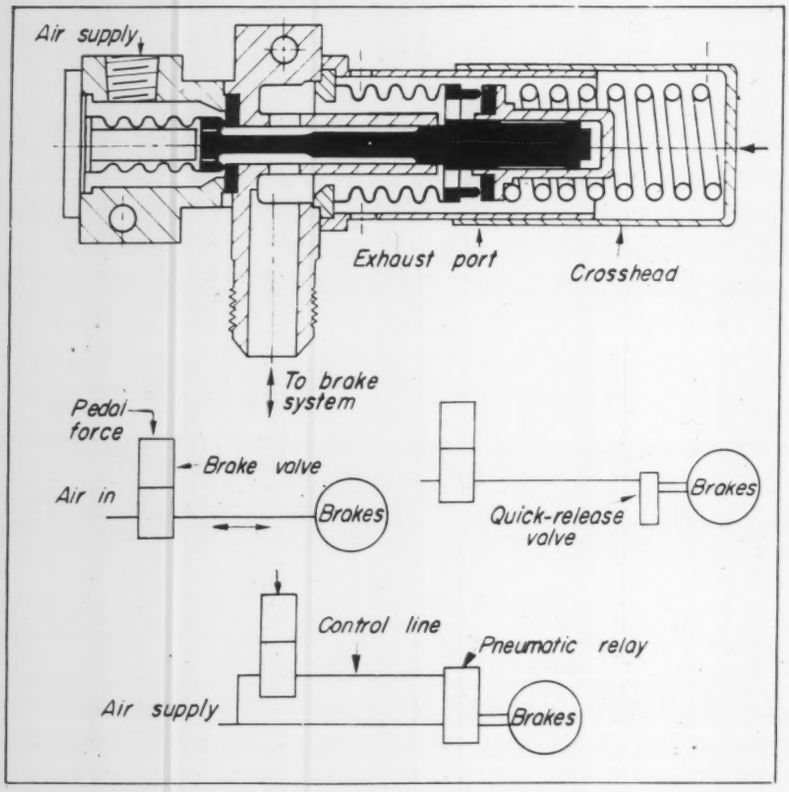


Fig. 35—Left—Proportional type brake valve for pneumatic braking, and schematic systems showing typical applications

Fig. 36—Below—Cross section of a characteristic quick-release valve for long pneumatic control lines which speeds exhausting of air

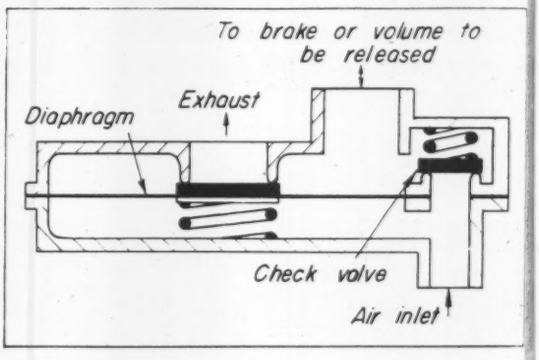
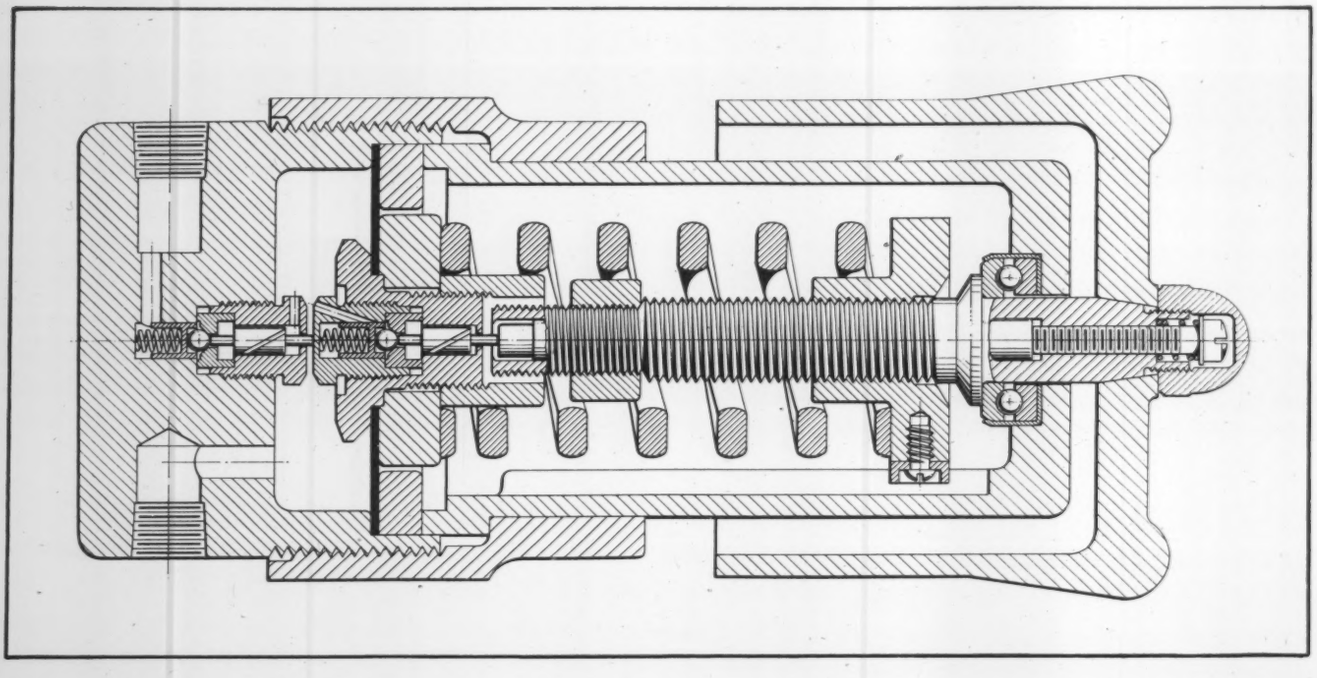


Fig. 37 — Below — Pressure-regulating valve which produces air pressure proportional to spring load. Spring load is proportional to position of screw and cap. Proportionality applies when output pressure is decreasing as well as when it is increasing

Photo, courtesy Grove Regulator Co.



ponents are made extremely small and the friction losses and sealing problems are serious. Pressures below 100 psi, therefore, are usually used. Components can be larger and more rugged, diaphragms and bellows can be employed easily, and the influence of foreign particles under valve seats and similar vital places in the mechanism is much less serious.

Several basic control systems will be described to illustrate and explain the operation of the various components. Pneumatic braking for automotive or aircraft service is a good example where (1) low reaction time is required, (2) high loads are involved, and (3) braking effect should be proportional to both pedal (or lever) depression and pedal force. Schematic braking arrangement as well as a brake valve that accomplishes the foregoing requirements is shown in *Fig.* 35. The reaction time with this particular valve is shown in *Fig.* 32. A pneumatic relay would lower this time somewhat.

Pressure Proportional to Valve Crosshead Position

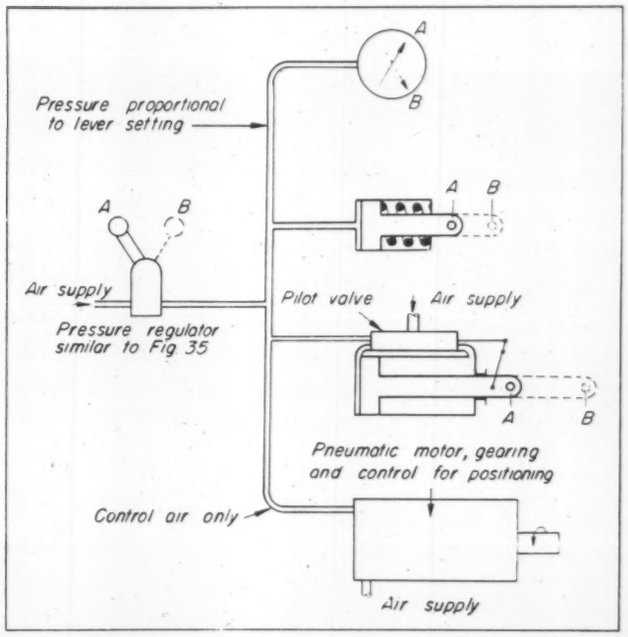
It is of interest to note that there is a definite line size needed to obtain the minimum reaction time with a particular system. If the line is too small for the capacities involved, there will be excessive frictional pressure drop and hence a long reaction time, whereas if the line is too large, considerable air is required to fill it and it takes time to pass this air through the valves. Although reference is made only to brakes, this same system can be applied in many other cases where an air pressure proportional to a force or to the displacement of the valve crosshead is desired. It is used for remote control of the throttle on large engines, for example.

The particular valve shown, *Fig.* 35, is designed with a large exhaust port so that a quick-release type valve is not required for short-line applications. A characteristic quick-release valve, shown in *Fig.* 36, is employed where long lines between the point of application and use would retard the time to drain the air and release the brakes or cylinder. The valve opens a large port and dumps air direct to atmosphere only when the control pressure is dropping. This valve should be located near the brake or the large volume of air to be released.

Since the controlled pressure is proportional to the depression of the valve crosshead, *Fig.* 35, or to the adjustment of the cap, *Fig.* 37, it is only necessary to provide an actuator that takes a position proportional to the pressure supplied to it and the result is an accurate remote-positioning system. This is shown schematically in *Fig.* 38 in several forms. If the actuator must handle large loads, power boost may be used with power from another source. Frequently the control line is ⅛-inch diameter tubing since only a small amount of air flows through it when a position change is made.

A standard pressure gage indicates a position proportional to the air pressure applied to it so it is quite simple

Fig. 38—Below—Schematic layout showing a group of accurate pneumatic remote-positioning systems



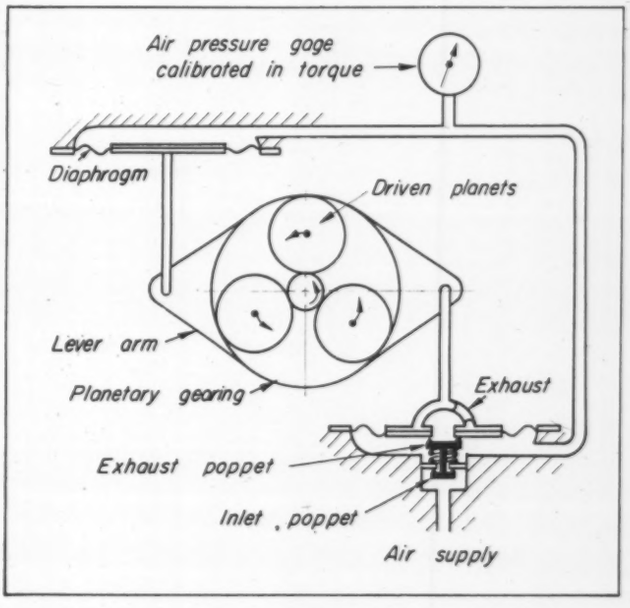
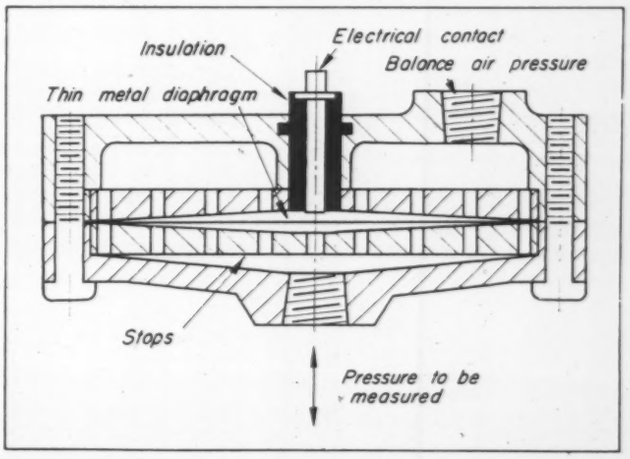


Fig. 39—Schematic of a remote-reading pneumatic torquemeter, a regulator which produces air pressure proportional to a varying force with but little change in position

Fig. 40—Below—Balanced-pressure type switch used to obtain special test data from engines, pumps and compressors



to indicate pneumatically the position of a remote device; merely use a small pressure regulator similar to that shown in *Fig.* 37 connected to the mechanism to set a pressure proportional to the position. A small tube applies this pressure to a gage calibrated in the desired manner. Some aircraft type pressure regulators are smaller than a package of cigarettes and often these regulators weigh only a few ounces.

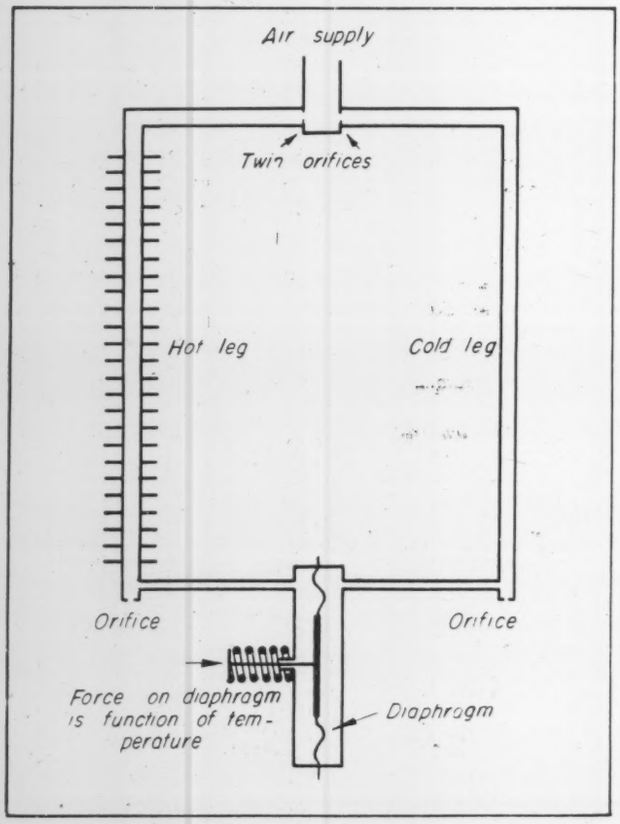
It should be noted that these pressure regulators differ from a pressure-reducing valve because they will bleed air from a closed system to lower the pressure as well as apply air pressure to it when changing the setting. Pressure-reducing valves will not do this.

Regulator Used as Torquemeter

A regulator designed to produce an air pressure proportional to a varying force with but little change in position is shown in *Fig.* 39. This type of unit is used to indicate torque on test-stand dynamometers or in aircraft engines. For test-stand work, a large-diameter diaphragm is used for low pressures and the pressure is read with a mercury manometer to obtain accuracy. Operation of the valve is self-evident in *Fig.* 39.

Another interesting application of compressed air in control and test work is that of the balanced-pressure switch, *Fig.* 40, used in obtaining special types of indicator cards for engines, compressors, and pumps. The upper chamber is preloaded to the desired pressure with compressed air so that the thin metal diaphragm cannot make contact and close the electric circuit until the cylinder pressure has exceeded the preload pressure. By obtaining the relation between this closing point and crank angle, a series of points can be taken at varying preload pressures to obtain a complete indicator card. This same unit is sometimes used to measure reaction time in pneumatic systems.

Fig. 41—Double orifice type pneumatic temperature-sensing device which uses air directly as sensing medium



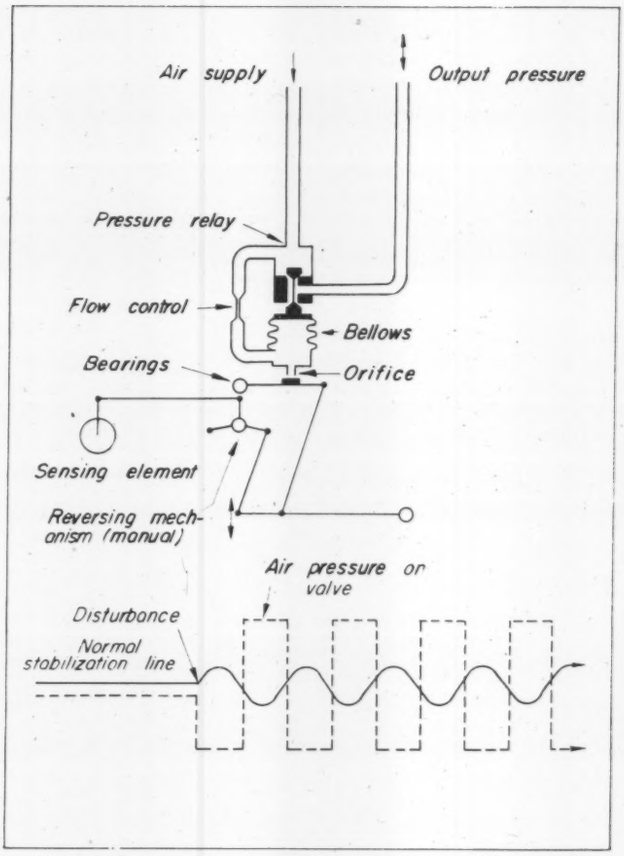


Fig. 42—Pneumatic power boost with temperature-sensing element provides on-off type control. Stabilization curve shown at bottom is characteristic

Direct or Power Boost Temperature Control

Pneumatics lends itself to temperature control in several ways. The air can be used directly as the sensing or measuring element as shown in *Fig.* 41, or other means may be used as the sensing element and pneumatic power boost applied as shown in *Figs.* 42, 43, and 44. In *Fig.* 41 the air flow is divided by two identical orifices into two tubes, one being passed through the heated area and the other maintained at as nearly uniform temperature as possible. The air must pass through a second orifice at the end of each tube. At this point, however, the air in one tube is considerably hotter than the other. From Equation 15 it can be shown that the pressure ratio in the two tubes is a function of the temperatures in the tubes since the same weight of air must pass through each leg of the system when the pressure drop across the first set of orifices is sufficient. While this system is very simple, it does not give an absolute temperature because conditions on the first leg may vary.

Compressed air for power boost is frequently used in process control work where, for example, a valve must be positioned to maintain a preselected temperature at some

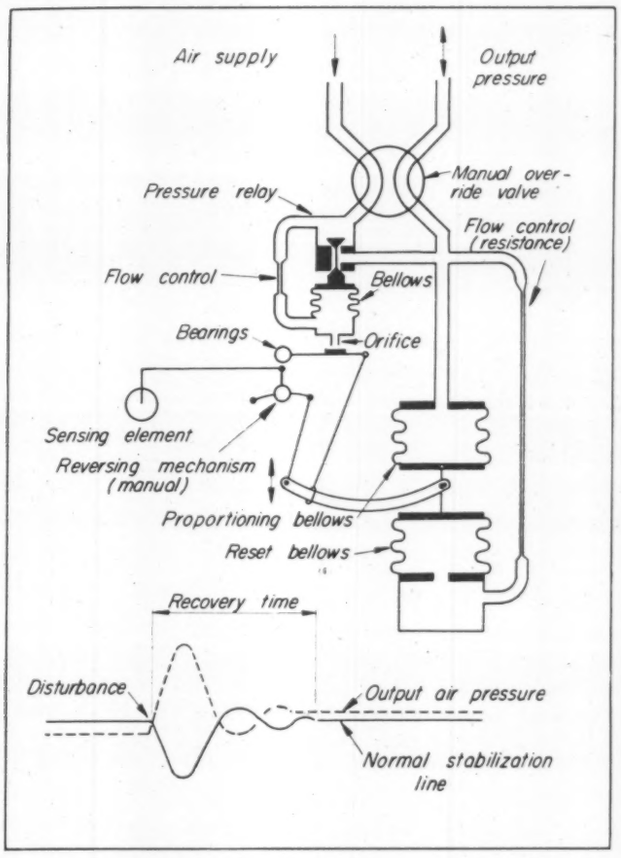


Fig. 43—Pneumatic power boost temperature control arrangement providing proportional control. Typical stabilization curve is shown

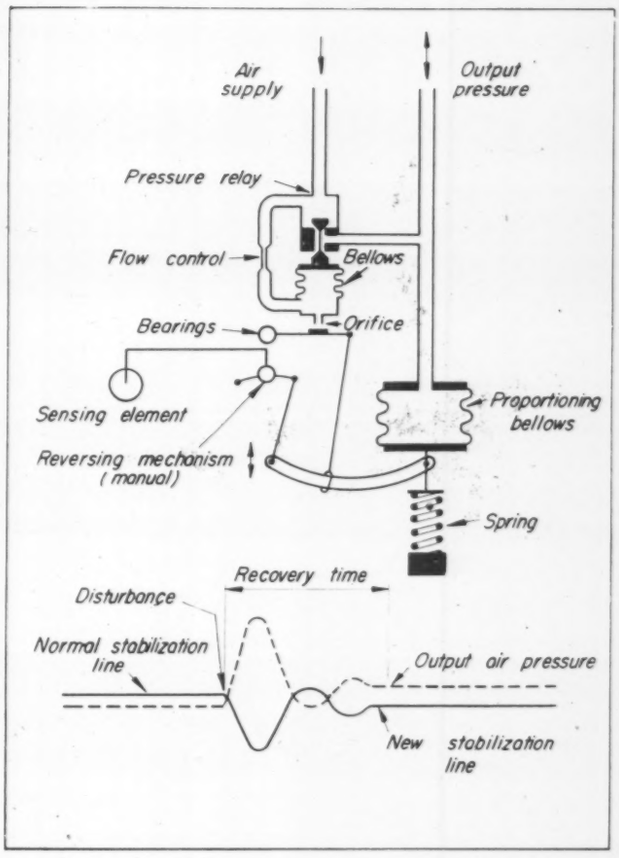


Fig. 44—Pneumatic power boost temperature control arrangment providing proportional-reset control. Stabilization curve shown is typical

station in the process or to maintain the pressure in the system. *Figs.* 42, 43, and 44 illustrate schematically the three basic control systems to do jobs of this type. The measuring or sensing element may be a bimetallic strip for temperature, a Bourdon tube for pressure, a float device for liquid level, or any other scheme to sense a change of conditions. The variable-output air pressure would be connected to some actuating device that influences the conditions to be controlled—for example, a diaphragm-operated steam flow-control valve in a temperature-sensitive system. The air supply in these systems should have most of the water and oil removed and the pressure should be reasonably constant, although slight changes have no effect.

On-Off System Cannot be Stabilized

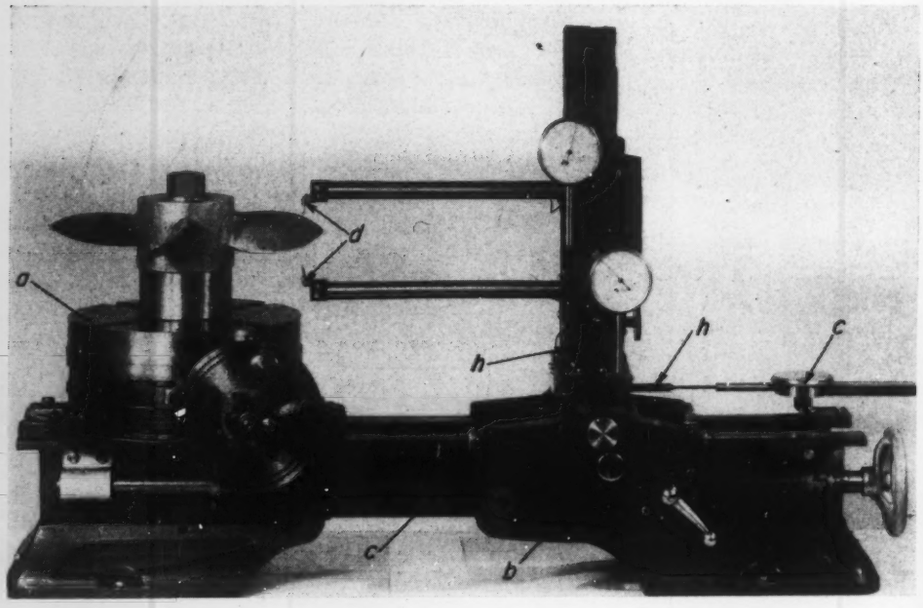
An on and off control system is shown in *Fig.* 42. Very slight change in the process causes a movement of the sensing element which opens or closes the orifice. This causes maximum or minimum output air pressure because of the action of the bellows on the three-way control valve. The actuating device responds instantly. This system is recommended for single-capacity systems with a high capacity-demand ratio and therefore covers the majority of applications. It should be noted that this system cannot be stabilized.

A proportional type control and its stabilizing effect are illustrated in *Fig.* 43. This is similar to the on-off control with the addition of a spring-loaded bellows operated from the output pressure to control the position of the valve over the orifice according to the demand on the system. Within limits the valve opening on the orifice and the output air pressure are always proportional to the displacement of the sensing element from normal. Maximum and minimum air pressure is not applied to the output system except when the measuring element displacement is so great that the proportioning band is exceeded. This control is generally applied where the capacity-demand ratio of the process is small. If a small proportional band is not maintained, a large change of control point occurs that may not be desirable.

The proportional-reset type of control and its stabilizing effect is diagramed schematically in *Fig.* 44. This control is the same as the proportional control except that instead of a spring a bellows has been introduced and connected to reset the system back to the same control point after each change. A manual override valve is shown for special operations such as starting and stopping.

Control systems illustrated in this article are general and can be applied to many varied applications with modifications to fit each case, but they will serve to indicate the versatility of compressed air for this work. The equipment is inherently rugged and once installed requires a minimum of attention. A good example of this is the reliability of complicated air brake systems on railway equipment with severe use and minimum maintenance.

(End of series)



By F. R. Nitchie Jr.
Pennsylvania State College
State College, Pa.

Measures Contours of Surfaces

IN CONNECTION with research on torpedo propulsion systems, it was found necessary to measure the dimensions of marine propellers to tolerances much smaller than those generally accepted in the manufacture of such items. The instrument developed should prove useful for any application requiring the measurement of radial or concentric cylindrical contours or sections, particularly of irregular surfaces.

The instrument shown was designed and built by the Harvard Underwater Sound Laboratory. It consists of a short lathe bed carrying a Brown and Sharpe indexing head *a* on which the body to be measured is placed, and a carriage *b* on which are mounted the measuring elements. The rotating table is indexed so that the angular orientation of the body may be locked at known intervals as small as five minutes of arc. The position of the measuring elements along the track bed, and hence the radius at which measurements are made, is controlled by a lead screw *c* and a dial indicator. Vertical measurements are made by the two horizontal arms carrying at their ends two styli *d*.

These arms, both of which are parallel to the track, are moved vertically by a pair of racks and pinions on the vertical column of the instrument carriage. For applications in which only one surface with no undercuts is to be measured or in which interference permits mapping of only one surface at a time, either one of these arms and its pinion drive may be removed from the column. Dial indicators register vertical movement of these units. For measurements greater than the range of the dial indicators, space bars *h* are inserted between the indicator contact point and the opposing anvil. This system makes possible a complete survey in cylindrical co-ordinates of a surface or pair of surfaces up to 24 inches in diameter.

The surface to be measured is located on an arbor set in the center of the rotating table. To center and zero the measuring styli on the axis of the arbor and table, the arbor is replaced by a centering fixture. This fixture carries two steel needles centered on the axis of the rotating table in such a position that the measuring styli can make contact with them. When point-to-point contact has been established, the lateral position of the measuring carriage is locked so that all further motion will be confined to a vertical direction or one parallel to the longitudinal axis of the track.

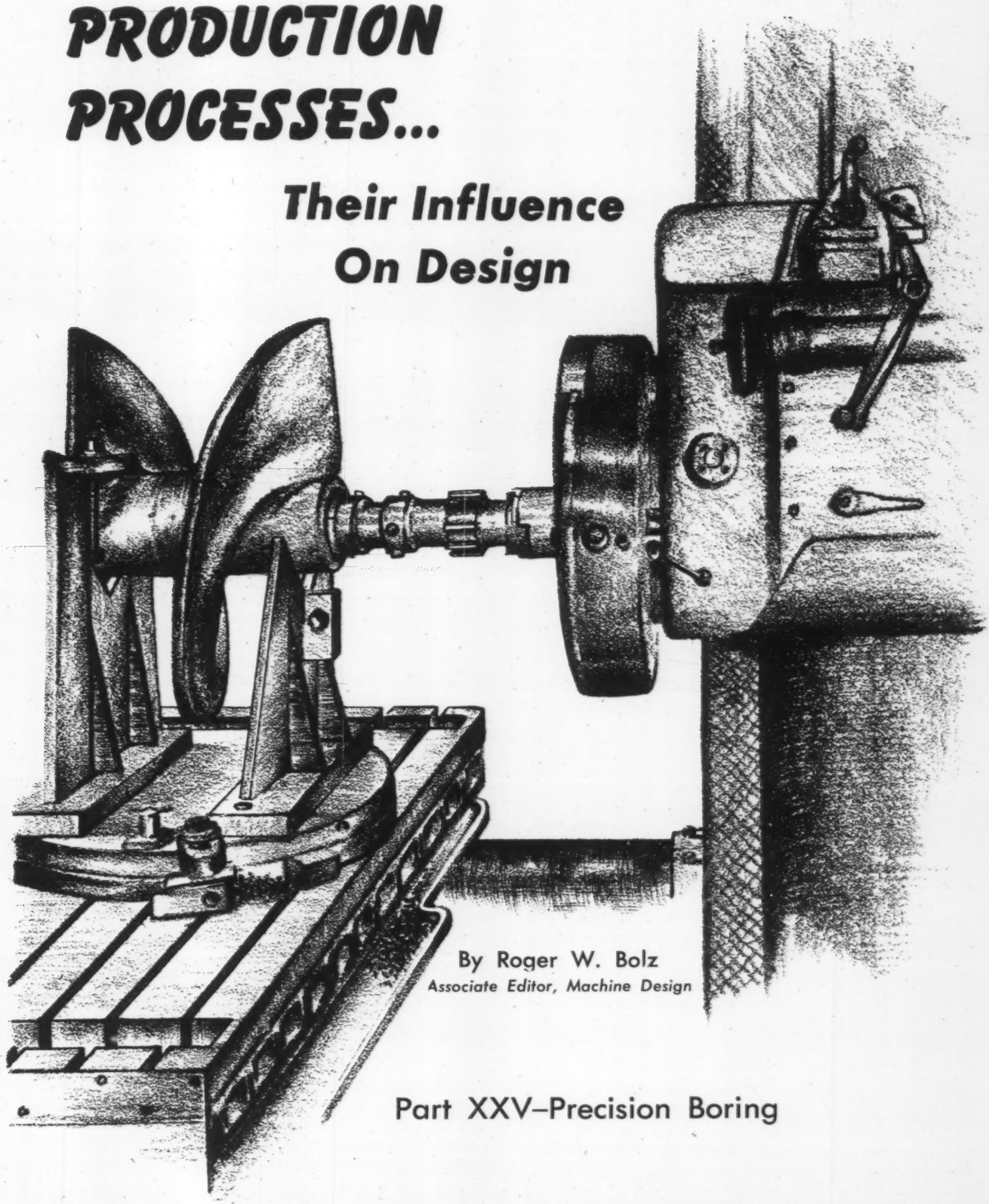
Neon Lamps Eliminate Arcing

The two styli are mounted on centers and spring loaded against adjustable stops. This permits adjustment of the individual styli, both vertically and laterally, while preventing damage from any overmotion. For convenience when mapping metal surfaces, the styli are insulated from the arms and are wired in series with neon lamps and a battery to indicate contact with the surface in question. This is particularly necessary in the case of an under surface normally hidden from the observer. Contact is made or broken by stylus motion of less than 0.0003-inch. The use of neon rather than incandescent lamps eliminates undesirable arcing at the surfaces.

Measurements with this device have been reproduced to within one thousandth of an inch. Greater accuracy might be obtained by mechanical modifications such as replacing the vertical racks and pinions by lead screws. To date, however, changing the structure has not been justified in order to obtain greater accuracy.

PRODUCTION PROCESSES...

Their Influence On Design



By Roger W. Bolz
Associate Editor, Machine Design

Part XXV–Precision Boring

THOUGH the specification of holes may seem commonplace and appear to deserve small attention, the increased accuracy of today's machine components demands serious consideration of boring requirements. The area covered in the field of precision boring is extremely wide both as to range of practical hole sizes and production tolerances commensurate with the design requirements. Too, hole spacings complicate the picture since accuracy of drive elements such as zero-backlash gears is rendered valueless where center-to-center distances cannot be held to the necessary limits.

Precision boring, performed with single-point, multitooth, form, compound, and special tools of almost unlimited variety on an equally diverse array of standard and special boring machines, ranks alongside milling in importance. Whether few or many parts are to be proc-

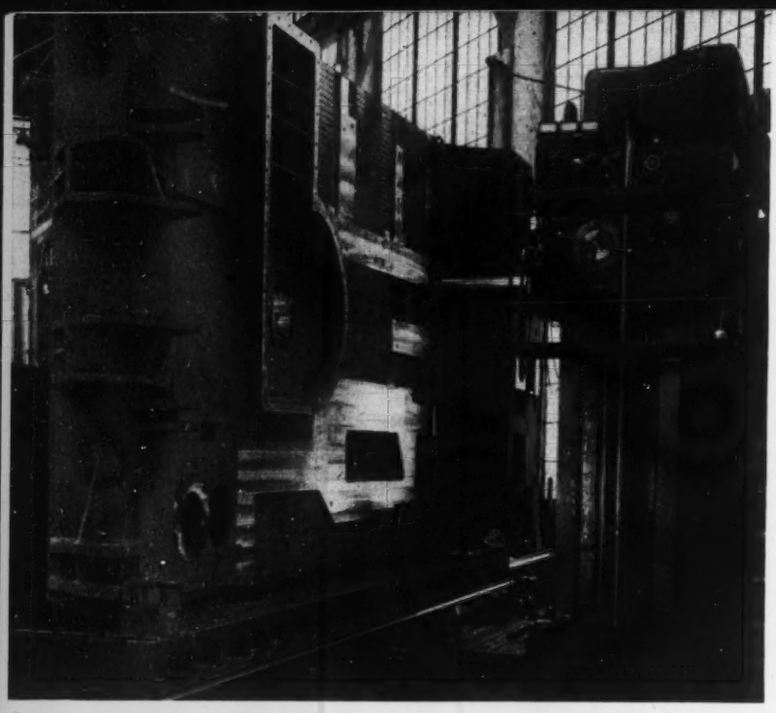
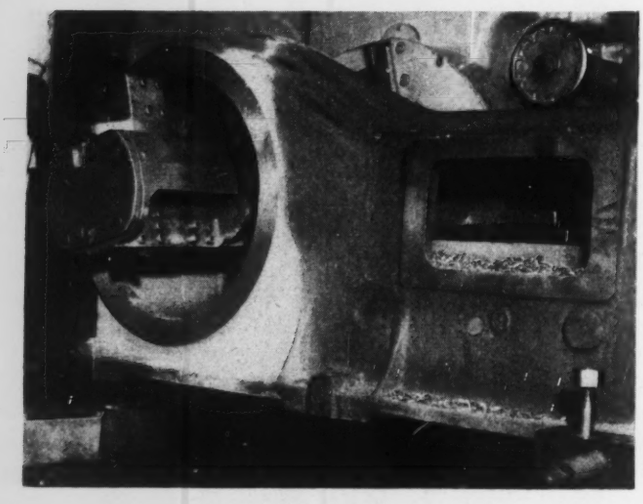


Fig. 1—Boring and face milling a large locomotive crane base weldment on a planer type machine



essed, equipment necessary for economical manufacture is readily available granting proper consideration of practical tolerances which can be held in continuous production, and also quantity or production speed.

Machine parts designed for boring may range from small pump units to extremely large frames and bases, *Fig.* 1. Although most bored holes present few problems, their relation to the remainder of the design is highly important and it is in this phase that most difficulty is experienced. In fact, it is because of this that most boring machines available today, excepting possibly highly specialized ones, are extremely versatile and include provisions for performing many additional operations such as milling, facing, drilling, tapping, etc., *Fig.* 2. Too, provisions are also made for rapid, accurate location of bores without special fixtures or measuring devices.

Available boring equipment may be divided into two distinct categories, the horizontal and the vertical. With horizontal boring machines, the work is held stationary on a table having in and out as well as back and forth movements, and the boring tools revolve while being fed into the work. Vertical boring mills, however, revolve the work on a circular table while the tools, much as in a vertical turret lathe, are fed into and away from the work. Large parts such as shown in *Figs.* 1 and 3 are normally machined on the large universal horizontal machines. These are usually of the planer type, table type with standard or revolving tables, floor type, or multiple-head crossrail type machines. Many variations and adaptations of these models are also available, extending the scope and capacity range considerably for the designer. For convenience, parts whose length, or height, is less than the diameter are machined in a vertical boring mill. Clamped to the rotary table of these mills, parts such as plates, turbine bucket wheel forgings, crane wheels, and the like can be turned and faced as well as bored.

Smaller parts, to be produced in low, medium, or large quantities, are handled more economically on single, or double-end automatic machines, one version of which is shown in *Fig.* 4. These machines are easily adapted to design changes and provide increased production speed.

Fig. 2 — Left Center — Facing and boring crankshaft bores in pump housings with a continuous feed boring head

Fig. 3—Left — Machine frame weldment being bored on a large planer type horizontal boring, drilling and milling machine using remote control

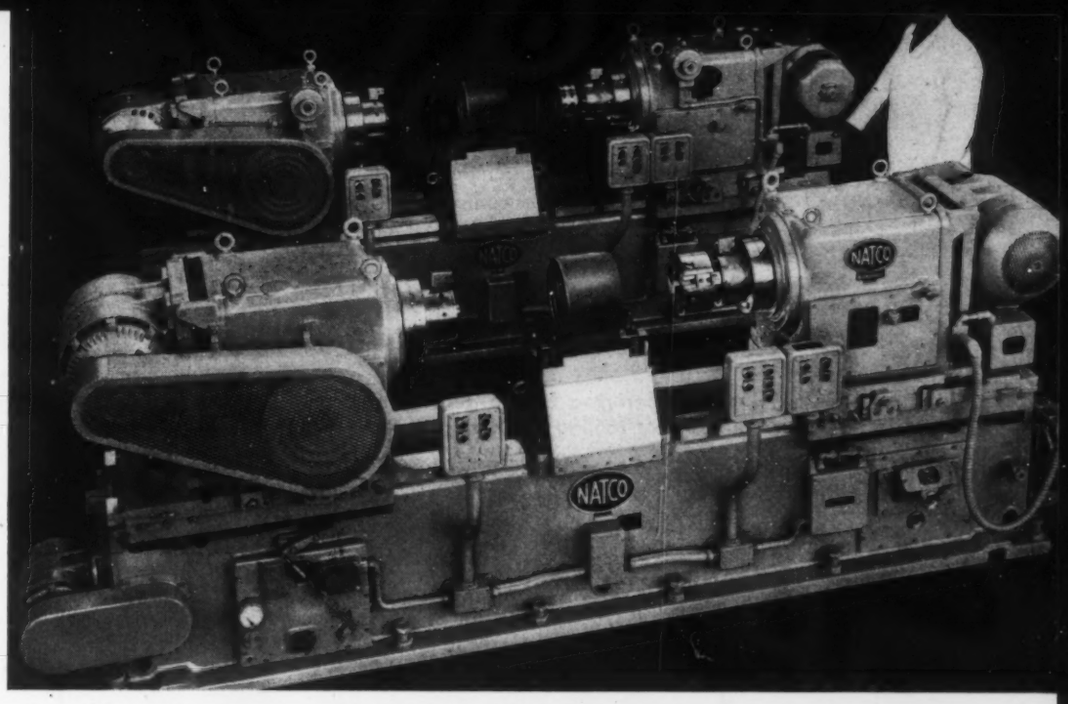


Fig. 4 — Right — Double-end machines, foreground, set up for rough boring and, in background, for finish boring a range of 8 sizes of motor shells in production

Fig. 5—Right Center — Maximum production of precision bores is provided by special automatic boring machines. This gray iron housing requires but 43 seconds to complete the five bored holes.

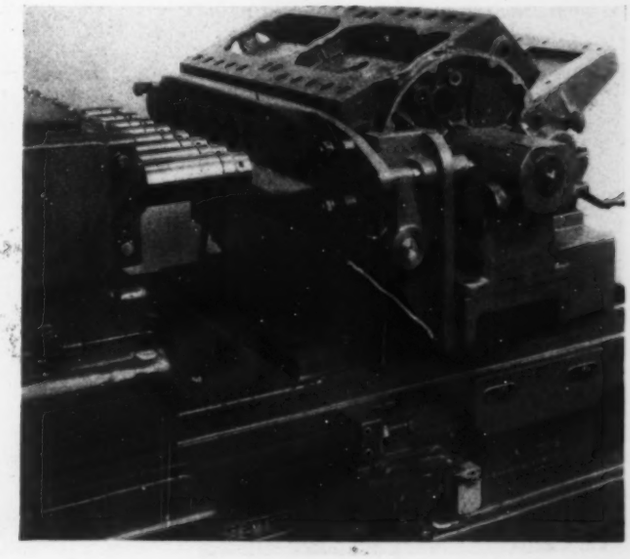
Other higher precision machines accommodate a range of bores from around 6 inches on down to extremely small-bore parts such as valve bodies, pistons, etc., *Fig.* 5. Units may be of standard design with single-spindle, single-head construction, multiple-head or, in some high-production cases, of special multiple-spindle design such as that shown in *Fig.* 5. On standard machines of this type, table travel ordinarily is about 18 inches maximum.

Entirely special machines for extremely large production precision boring are designed primarily for maintaining exact hole spacings and alignment, *Fig.* 6. Inasmuch as many parts, both by design and quantity, fall outside the scope of economy considering totally special machines, the jig borer is normally resorted to for precision results, *Fig.* 7. Where accuracy is such as to be beyond the scope of drills and drill jigs, the part too fragile to withstand heavy cutting loads, or the material subject to poor finish by ordinary methods, the jig borer is especially well suited. Placed in a fixture, the part can be finish-bored in the sequence required, by means of the gaging features on these machines, without relocation of the part during the process. As can be seen in *Fig.* 7, interchangeable heads are provided where bores vary more than ⅛-inch to simplify and speed production.

Fine boring on most of these machines is based primarily upon the facility with which a single-point tool will generate a straight, round hole. Too, if the tool is tipped with diamond or cemented carbide, high speeds and fine feeds will produce bores to limits of accuracy and surface finish unobtainable by other means. Bores for parts such as bearings, piston pins, connecting rods, etc., where size, roundness and alignment are paramount, preferably should be generated by single-point, high-speed tools. Cutting speeds of about 450 surface feet per minute on cast iron and up to 1500 sfpm on aluminum and magnesium alloys are regularly used with feeds from 0.002-inch up.

Ordinary boring bars produce far less accurate results largely because of the running clearance necessary with the bushings that are used to guide them though, of course, they can produce more complicated bore designs and remove metal at a much faster rate. Thus on large

Fig. 6—Below—Production boring 16-cylinder Cadillac motor block. Unique fixture allows finishing of 16 bores



work, *Figs.* 3 and 4, single-point tools are often not used when production speed and quantity justify more expensive arrangements. Multipletooth cutters and form cutters are often employed in order to complete an entire part at one or two settings. However, practical hole tolerances, more expensive upkeep and the obsolescence factor must be contended with in such arrangements.

Like the large universal boring machines, the jig borer is not limited to small-lot production merely as a jig eliminator. It can be employed on medium and even large quantity work when, as noted previously, the required accuracies cannot be had by means of a jig. The aluminum stud, *Fig.* 8, is a good example of such a part. Required in a quantity of 5000 pieces, the holes were first drilled in jigs allowing about 0.012-inch for jig boring and then finish bored in a fixture to the limits shown. Total time per piece including milling the pads to height was 6 minutes, floor-to-floor.

With all these machines, however, production speed is limited to a great extent by the locating operations necessary. Consequently, where maximum quantity production must be attained with machine parts involving numerous precisely located bores which are not parallel and so not suited to production units such as those shown in *Figs.* 5 and 6, special "package" type machines can often be employed, *Fig.* 9. These machines, entirely automatic in operation, can be revamped readily to allow for design improvements in the parts produced and thus require only replacement of tooling for the units.

DESIGN: When specifying bores for any size machine part it is well to keep in mind the means by which the particular bore size, finish and accuracy can be produced. Of equal importance are spacing limits on multiple bores and also stepped bore complexity. Although, as indicated in the previous discussion, almost any design can be produced, whether the cost per part and normal production speed meet the practical requirements is another matter. The designer can do much to eliminate production problems by simplifying the design requirements as much as possible and recognizing the limitations imposed by too stringent tolerance limits.

Boring is usually an enlarging operation, sizing and finishing an existing hole that has been drilled, forged, punched, or cored. Drilling is usually considered for producing holes up to around 3 inches in diameter, and

Fig. 7—Below—Precision boring a bronze gear housing on a jig borer with special tooling for mass production

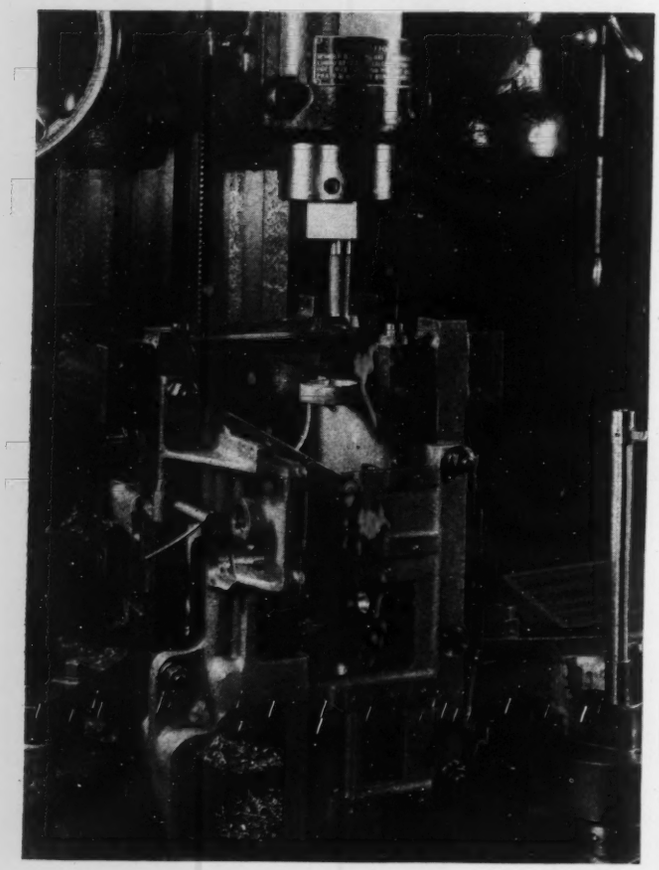


Fig. 8—Below—Aluminum stud jig bored to limits shown on a production basis required but 6 minutes per piece

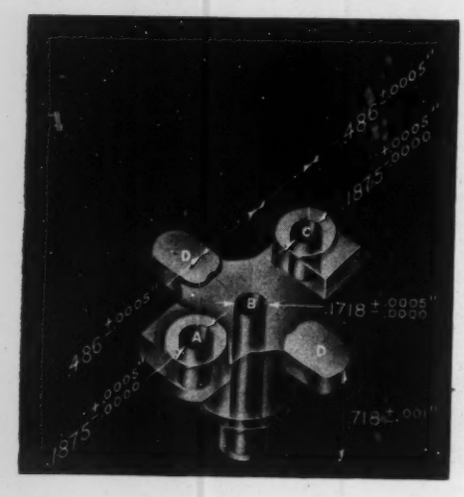
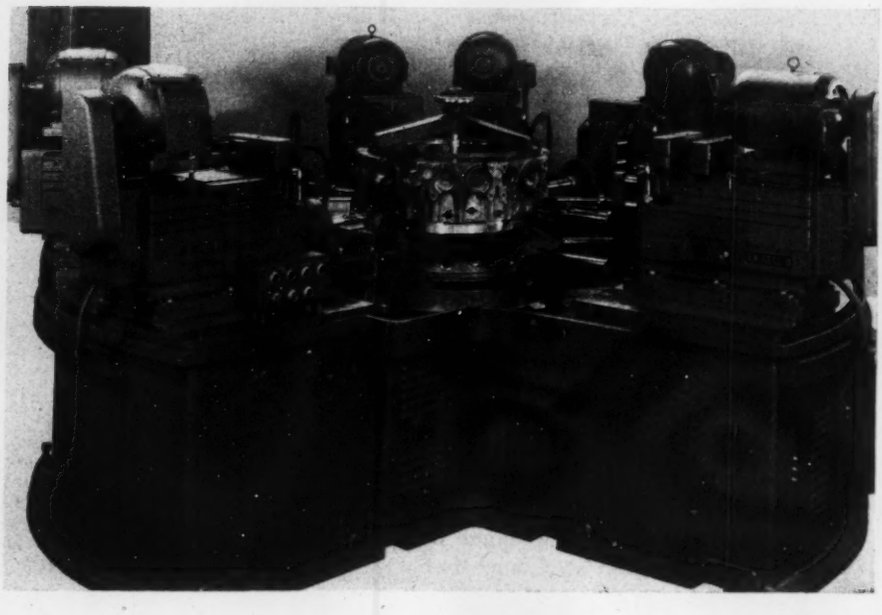


Fig. 9—Below—Core drilling, broaching and reaming as well as boring are employed in the automatic production of magnesium supercharger housings on this special multiple-head "package" unit boring machine



where close tolerances are necessary reaming, grinding or honing is used along with jigs to attain accuracy of spacings. Single-point boring, however, can be used, to assure much closer tolerances even with long bores without the use of jigs, only holding fixtures being necessary to locate and retain the part. Small parts often need no further finishing while large bores such as those for cylinders may require burnishing or honing.

Fragile, thin-wall designs should be avoided wherever possible to make possible maximum cutting speeds and feeds and obviate inaccuracies from distortion. Where such designs are necessary, though, the jig borer provides a ready means for holding extreme accuracy on small parts by using single-point tools, *Fig.* 10. The brass wave guide shown in this illustration not only posed a clamping problem but required the internal semicircular surface to be machined to a radius of 1.419-inch, plus 0.001-inch and minus 0.000, offset 0.062-inch from the hole centerline.

The problem of locating and holding a part in a fixture should always be kept in mind. Where ready, positive location is not possible, lugs should be provided for this purpose. The radar drive gear housing shown in *Fig.* 11 is a good example. Locating lugs are machined along with the largest flat surface and after serving to locate and hold the casting for finish boring, are removed.

Closely spaced bores on different levels require consideration since for maximum accuracy long tool extensions from the boring spindle should be avoided. It is well to ascertain beforehand the clearance available on the machine to be used, *Fig.* 12.

In dimensioning a multiplicity of bored holes and especially hole circles, rectangular coordinates should always be used in preference to polar or angular coordinates. Although polar coordinates are simpler to lay out and calculate and often more convenient to use, especially with a rotary table machine, the rectangular ones are invariably

Fig. 12—Vertical-spindle borers feature rapid spindle feed, simplifying boring at different levels

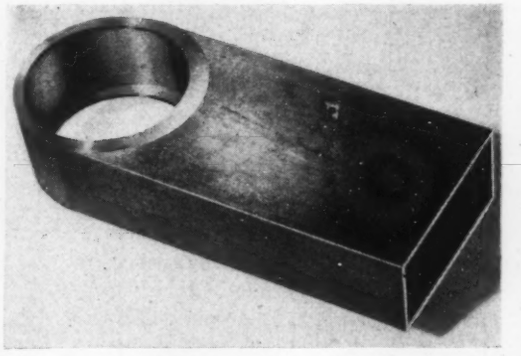


Fig. 10—Above—Brass radar wave guide, 6000 of which were finished, poses a difficult boring problem because of extremely thin walls

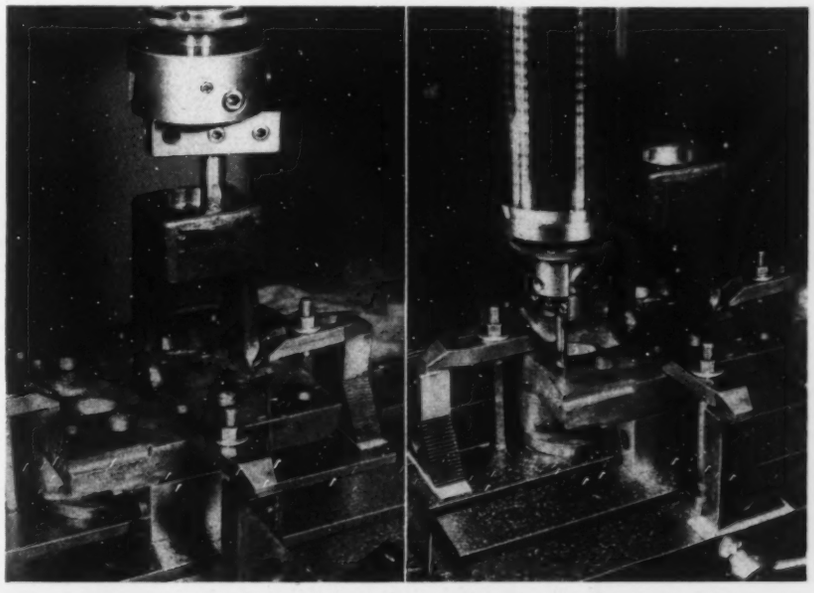
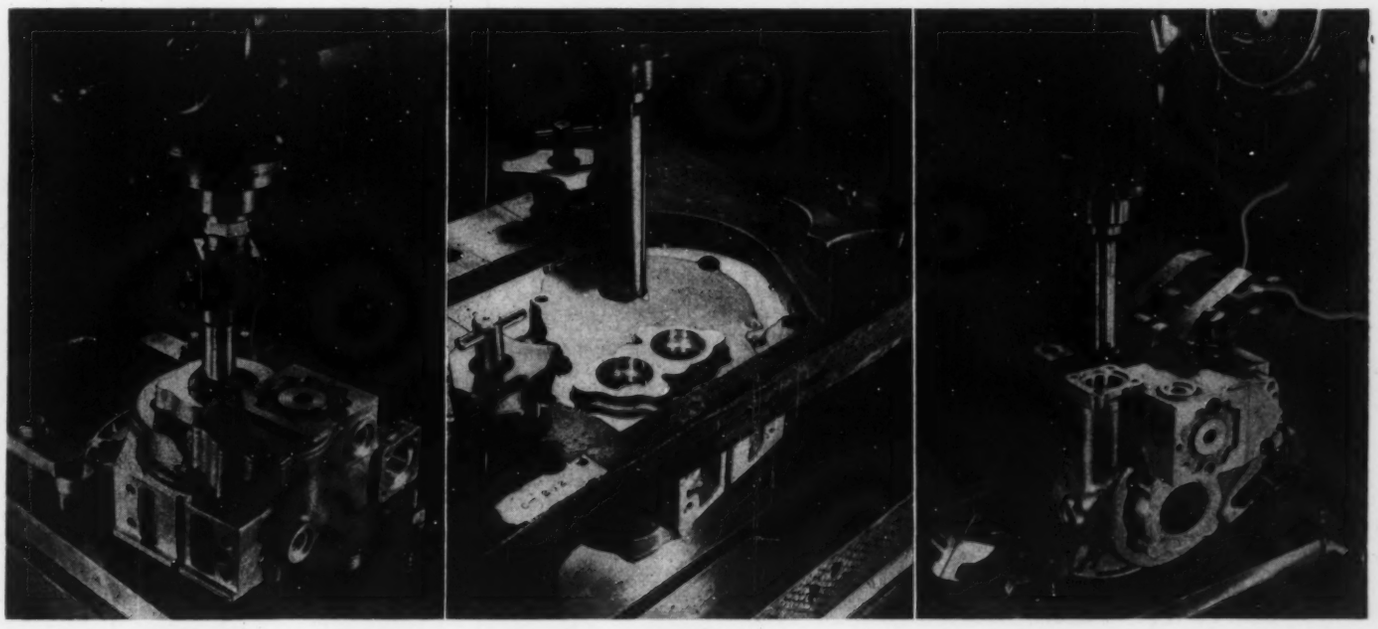


Fig. 11—Below—Radar drive gear housing utilizes cast-on lugs for locating and holding during boring. After completion of the machining, the lugs are cut off



the most accurate. This is because of inaccuracies which creep in when picking up the center of the rotary table with respect to the machine spindle, errors in picking up the center of the work piece with respect to the table and spindle, dividing system errors, and errors in reading. Calculation of coordinates, however, can be reduced to a relatively easy procedure by applying the principles outlined in the Woodworth "Circular Tables of Coordinate Factors and Angles" *.

MATERIALS: For the most part the relative suitability of materials for economical boring parallels that discussed in the previous articles on milling, Parts XXII and XXIII of this series. Of interest is the fact that many nonferrous bearing metals, aluminum, etc., do not finish to desired surface quality with drills or reamers but spall and pick up. Normally these materials require heavy cutting pressure for best results and consequently, where maximum surface quality and accuracy are desired, single-point boring may be necessary and preferable. In such cases the speeds and feeds common to fly-cut milling would apply for optimum results.

*Included in the book *Precision Hole Location*, by J. Robert Moore, published by the Moore Special Tool Co., Bridgeport, Conn.

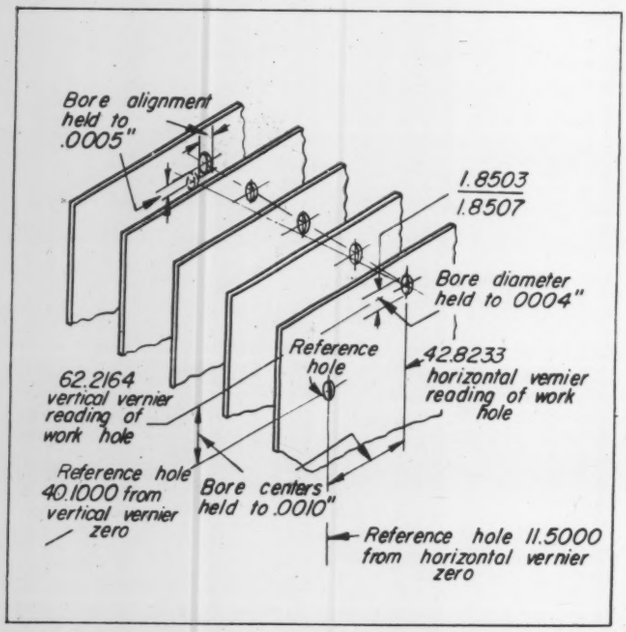
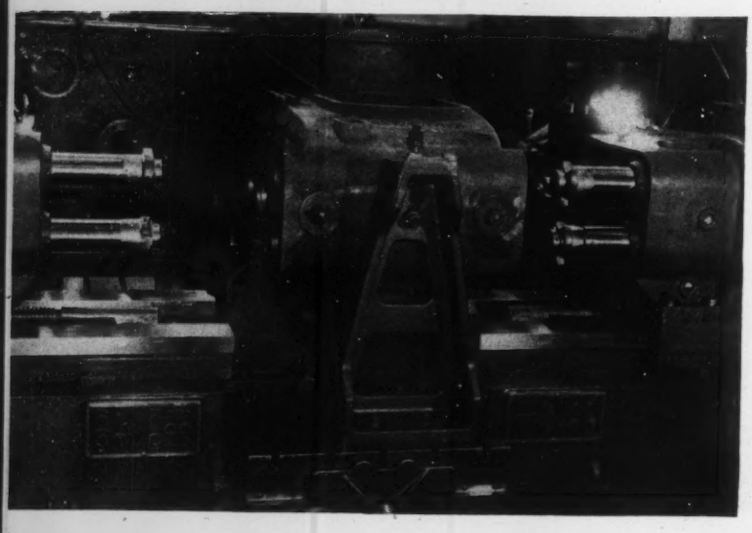


Fig. 13—Above—Sketch showing limits held in hole location and diameter on a horizontal boring machine

Fig. 14—Below—Special double-end machine for production boring simultaneously the overarm, spindle bearing and primary shaft holes in cast iron milling machine frame. Special carbide tipped cutters are used



TOLERANCES: Naturally, as with any production job, widest possible tolerances provide maximum economy in manufacture. Extremely close tolerances can be held in boring but usually incur additional operations, many times necessitating a rough boring, semifinish and finish boring operation. Final precision is often dependent upon uniform stock removal in the finishing pass. Jig borer or fixture and gage tolerances should seldom be demanded, except in legitimate cases of precise gear trains and like design problems. Where but a few pieces are to be produced the extra time involved is of small consequence but becomes a costly feature with large quantities.

On large table type machines, bores as large as 24 inches can be readily held to plus or minus 0.0005-inch with a suitable machine, smaller bores to even closer limits, *Fig.* 13. However, plus or minus 0.001-inch on holes up to 6 inches and greater limits with increasing diameter are much more readily produced. Bores in *Fig.* 14 are held to plus or minus 0.0002-inch in production.

Close Tolerances Readily Attained

Single-point boring on machines such as shown in *Fig.* 5 can be held to plus or minus 0.0001-inch even on very thin-wall parts. Piston pin bores are regularly produced to these limits while being held perpendicular to the skirt within plus or minus 0.0002-inch and alignment within plus or minus 0.0001-inch. With single-point carbide or diamond tipped tools, these bores can be produced repetitively to 0.0001-inch maximum variation from piece to piece. Larger bores with such machines, *Fig.* 4, ranging up to 15 inches in diameter can be held to plus or minus 0.001-inch on diameter and concentricity in mass production with a rough and finish operation.

Jig bored parts such as shown in *Figs.* 7, 8 and 11 are readily held to limits indicated generally in *Fig.* 8. Again, however, it should be stressed that only those dimensions absolutely requiring extremely close tolerances should be so specified to simplify production and reduce costs.

Hole location where necessary can be held within plus or minus 0.0005-inch on any precision boring machine ordinarily and, in some cases with jig borers, to plus or minus 0.0001-inch. Blind hole depths can be held to plus or minus 0.0005-inch but a tolerance of plus or minus 0.001 to 0.005-inch is more practical. Threads can be held to a class 3 fit on large parts while those produced on jig borers can be held to class 4 fit.

Collaboration of the following organizations in the preparation of this article is acknowledged with much appreciation:
Ex-Cell-O Corp. (*Fig.* 9) ..... Detroit
Giddings & Lewis Machine Tool Co. (*Figs.* 1, 2, 3, and 13) ..... Fond du Lac, Wis.
F. F. Gilmore & Co. ..... Boston
Heald Machine Co. (*Fig.* 6) ..... Worcester, Mass.
Kearney & Trecker Corp. (*Figs.* 12 and 14) ..... Milwaukee
The Maytag Co. (*Fig.* 5) ..... Newton, Iowa
Moore Special Tool Co. Inc. (*Figs.* 8, 10 and 11) ..... Bridgeport, Conn.
National Automatic Tool Co. Inc. (*Fig.* 4) ..... Richmond, Ind.
Warner & Swasey Co. (*Fig.* 7) ..... Cleveland

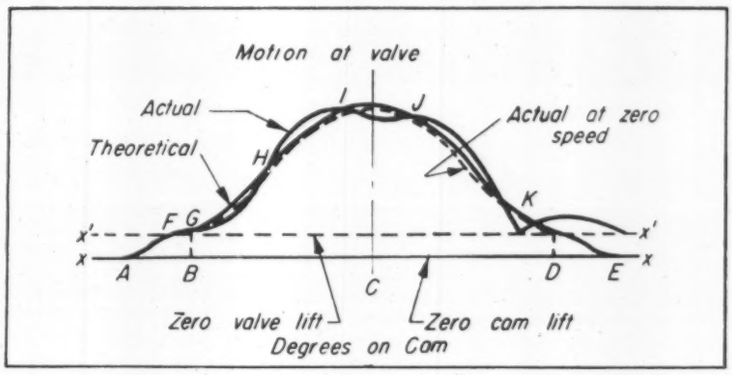
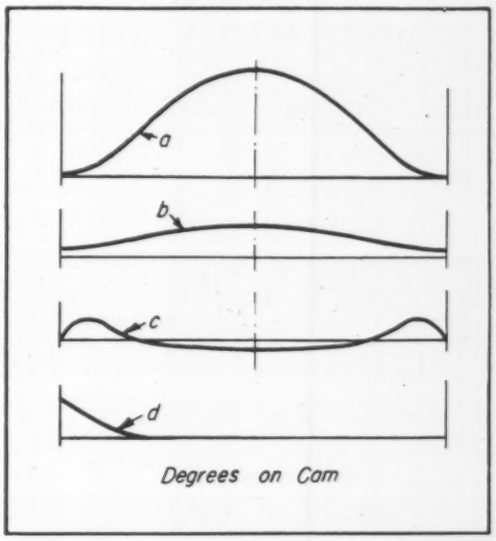


Fig. 1—Left—Typical record of actual valve motion at operating and at slow speed

Fig. 2—Below—Curves representing valve motion (a) and the forces resisting it, which consist of spring force (b), inertia force (c), and gas pressure force (d)



A New Approach to Cam Design

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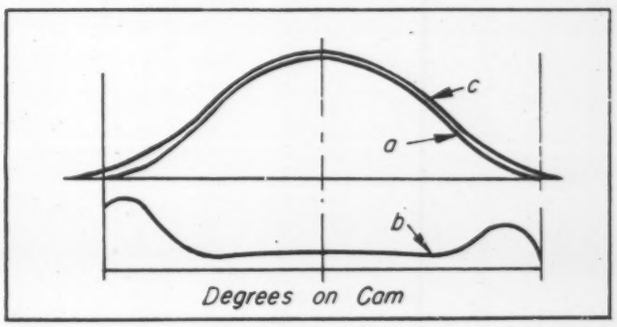


Fig. 3—Resultant cam profile (c) is the sum of actual valve motion desired (a) and the deflection (b) required to create the necessary driving force at the valve

CONVENTIONAL CAM DESIGN procedures fail to insure smooth action at high speeds because deflection effects are ignored. A rational method which has been applied successfully to the calculation of cam profiles for high-speed engine valve mechanisms is presented in this article, which is based on a recent SAE paper. The method is equally applicable to other cam-operated mechanisms

IT HAS been customary to blame improper action of internal combustion engine valves on "surge" of the valve springs. However, during a research program on self-adjusting valve mechanisms it was noted in several cases that the use of stronger springs and surge-damping devices failed to raise the engine speed at which noisy valve action set in. When records of actual valve motions, using a stroboscope or a high-speed camera, were superposed on the theoretical valve motion as determined by the cam profile, it was seen that the chief cause of bad valve motion was flexibility in the linkage.

A typical record is sketched in *Fig.* 1. From *A* to *F* the cam removes the clearance or "lash" in the system. Contact occurs at *F*, but the valve does not begin to move until *G*, as the linkage must be compressed until it can balance the forces of the valve spring and any gas pressure in the cylinder.

At slow speeds, the actual valve motion is as shown by the dashed curve; it will follow the cam except for the static deflection caused by the valve spring force. At high speeds, however, the inertia forces cause much greater deflections, as shown by the heavy line. The valve arrives at *H* with a greater velocity than was contemplated in the design of the cam and springs; above a certain speed a jump will occur.

The jump ends at some point such as *I*. As the relative velocities at impact may not be high, the effect would not be serious except for what happens after. The valve lands on the elastic valve train like a man jumping on a springboard, and usually "takes off" for another jump at *J*. If this one lasts long enough, the valve will strike its seat at *K* at a speed far beyond safe limits, and may rebound as shown. Under such conditions, the opening and closing velocities on the cam profile have nothing to do with those actually occurring at the valve.

Thus the conventional cam design procedure fails because it assumes complete rigidity of the parts between cam and valve. Actually, in a large, radial aircraft engine at takeoff speed the sum of forces due to inertia, valve spring force and gas pressure may be a ton or more, re-

TABLE I— Characteristic Factors of Various Cam Curves

Powers of θ Used	Area Factor b	Max. Velocity		Max. Positive Accel.		Max. Neg. Accel.	J-Value (Eq. 5)
		Location $\frac{\theta}{a}$	Value	Location $\frac{\theta}{a}$	Value		
Using Equation 11							
2-4-6-8	0.4571	0.4472	1.717h/a	0.7746	4.800h/a²	—6.00h/a²	14.63h²/a³
2-4-6-8	0.5000	0.5371	1.702h/a	0.8393	5.929h/a²	—4.31h/a²	14.05h²/a³
2-4-6-8	0.5400	0.6013	1.827h/a	0.8605	7.396h/a²	—3.95h/a²	16.55h²/a³
2-4-6-8	0.5800	0.6378	2.028h/a	0.8706	8 970h/a²	—5.09h/a²	21.96h²/a³
Using Equation 15							
2-4-6-8	0.4354	0.4114	1.782h/a	0.7165	4.720h/a²	—6.86h/a²	16.20h²/a³
2-6-8-10	0.4848	0.5117	1.768h/a	0.7924	5.800h/a²	—4.50h/a²	14.95h²/a³
2-8-10-12	0.5164	0.5784	1.772h/a	0.8355	6.902h/a²	—3.69h/a²	15.41h²/a³
2-10-12-14	0.5385	0.6270	1.780h/a	0.8636	8.011h/a²	—3.28h/a²	16.38h²/a³
2-12-14-16	0.5548	0.6642	1.790h/a	0.8834	9.125h/a²	—3.03h/a²	17.57h²/a³

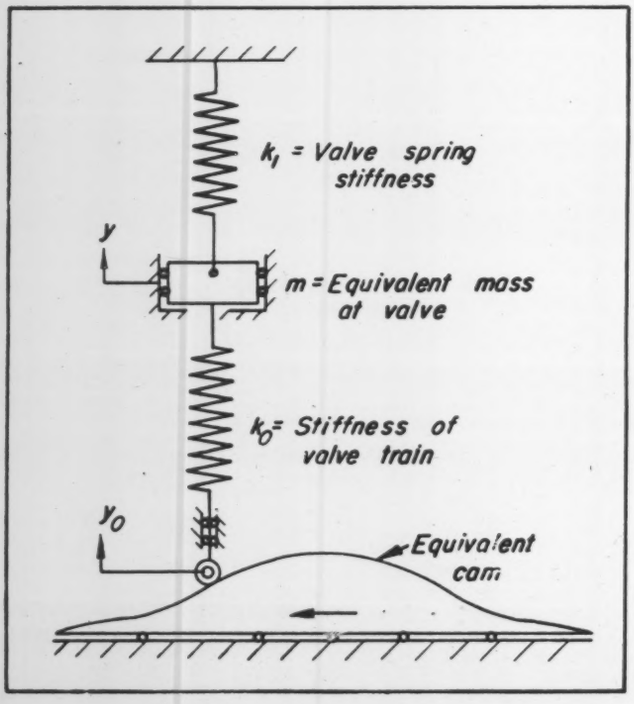
sulting in deflections of the order of ⅛-inch at the valve.

Some improvement can be obtained by stiffening the valve linkage, but this will add weight and require increased force from the valve springs. A better approach is as follows: The desired valve motion can be specified, and it is then possible to calculate the cam profile which, acting through the flexible valve linkage and at a given speed, will cause such a motion to take place. Thus, the proposed cam design process requires two steps:

1. Specify the actual valve motion desired (this is called the "net" valve motion)
2. From a knowledge of the weights, stiffnesses, gas pressures, valve motion ratio, etc., calculate the corresponding cam profile. When multiplied by the valve motion ratio, this is the "gross motion"; it is the valve motion as it would be with no deflection in the system.

How such a cam can be assembled is shown in *Figs.* 2 and 3. The actual valve motion desired at a given speed is shown in *Fig.* 2*a*. From its equation, the forces exerted on the valve by valve springs and inertia can be computed, and are shown in *Fig.* 2*b* and *c*. The gas pressure force, *Fig.* 2*d*, can also be included if the necessary indicator-card data is available. However, present experience is not sufficient to determine whether the advantages of this feature outweigh the disadvantages. Deflection necessary in the valve linkage to create a driving force equal and opposite to the resisting forces of *Fig.* 2 is shown in *Fig.* 3*b*. The cam profile required, *Fig.* 3*c*, is the sum of *Figs.* 3*a* and *b*.

Fig. 4—Dynamically equivalent system for valve and valve mechanism, including stiffness of the linkage



VALVE AND CAM MOTION EQUATIONS: It has been found practical to reduce the valve mechanism to a dynamically equivalent system containing only four parts: The valve springs, an equivalent mass at the valve, a spring representing the elasticity of the valve linkage, and an equivalent cam giving motions as they would occur at the valve end of the rocker arm (or at the valve stem) with no deflections in the system. These parts are illustrated in *Fig.* 4 (see accompanying Nomenclature).

Considering the equilibrium of the equivalent mass m which follows the well-known law, applied force equals mass times acceleration, the force equation is:

$$m\frac{d^2y}{dt^2} = -F_o - k_1 y - k_o y + k_o y_o \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

As this equation gives the relation between y and y_o, it can be used in either direction. If an arbitrary cam profile $z = y_o/L$ is assumed, the resulting valve motion can be found. This must usually be done by a lengthy step-by-step calculation, with further complications if the force in the valve train falls to zero (indicating a jump). Work of this kind has been carried out in a number of cases, and good agreement secured with experimental determinations of valve motion. However, it is much simpler and more useful to "invert" the equation: A suitable valve motion y can be specified, and the equation then determines the necessary shape of cam to cause such a motion to take place at the chosen speed of the engine. Thus the formula for cam lift z is, changing the independent variable from time t to cam degrees θ:

$$z = \frac{1}{L}\left[\frac{F_0}{k_0} + \frac{k_0+k_1}{k_0}y + \frac{m}{k_0}\frac{36N^2}{c^2}\frac{d^2y}{d\theta^2}\right] \quad \ldots\ldots\ldots\ldots (2)$$

The slope of the cam at any point is:

$$\frac{dz}{d\theta}=\frac{1}{L}\left[\frac{k_0+k_1}{k_0}\frac{dy}{d\theta}+\frac{m}{k_0}\frac{36N^2}{c^2}\frac{d^3y}{d\theta^3}\right] \quad \ldots\ldots\ldots (3)$$

The acceleration of the cam profile is:

$$\frac{d^2z}{d\theta^2}=\frac{1}{L}\left[\frac{k_0+k_1}{k_0}\frac{d^2y}{d\theta^2}+\frac{m}{k_0}\frac{36N^2}{c^2}\frac{d^4y}{d\theta^4}\right] \quad \ldots\ldots\ldots (4)$$

In order to compute a cam lift curve from Equation 2, it is necessary to have an equation for y, the actual valve motion desired. It can be seen from Equations 2 and 4 that y and its first three derivatives must all be continuous functions. If this is not true, the computed cam lift z will contain sudden jumps or changes of slope. Thus, it is impossible to follow the traditional cam design procedure in which a series of straight lines, parabolas, etc., are fitted together to form a cycle of motion.

IDEAL MOTION CURVES: In *Fig.* 5 is shown a typical cam-design problem—to find a motion curve starting with zero velocity at A, and arriving with zero velocity at a displaced position B, in a given time or space interval. Since there is an infinite number of curves which might be used to connect A and B, the question arises: What is the best possible curve or mathematical function?

Nomenclature

- k_1 = Spring rate of valve spring, lb per in. (If more than one spring per valve is used, k_1 is the sum of the individual springs in a set)
- k_0 = Spring rate of valve linkage, measured at the valve end of the rocker arm (or on top of the valve in an L-head engine), lb per in.
- m = Equivalent mass at valve, including valve, washer, locks and part of spring and valve train masses. Units of mass = (weight/g) = (pounds/386) since g = 32.2 x 12 = 386 in/sec^2
- y = Motion (lift) of valve, in. This is actual or "net" motion, to be specified by suitable equations
- L = Valve motion ratio = valve motion/tappet motion, average value when forces in system are small. On L-head engines, L = 1
- z = Lift of tappet, measured from position in which all clearance or lash is taken up but there is no force in valve linkage
- y_0 = Gross motion = Lz. This is not the same as y because of deflections in the valve linkage
- F_0 = Force in valve springs in valve-closed position, lb
- N = Rpm of the engine at which the cam is to produce a specified valve motion. N is usually the highest speed at which the engine must regularly operate
- c = Rpm of crankshaft/rpm of cam = 2 for automotive engines, and 6 or 8 for radial engines.

In the case of valve motions, it is desirable to keep accelerations as small as possible, because in one direction these accelerations must be provided by the valve springs. Greater acceleration will require more force from these springs. This may mean larger and more expensive springs, difficulties with high stresses or space limits, more rapid wear from the greater loads on the mechanism, and limitations on speed.

Returning to *Fig.* 5, it is necessary to arrive at a mathematical statement of the problem in order to solve it. High acceleration is undesirable and, moreover, in the valve system it is physically impossible to have sudden changes in acceleration. Driving forces at the valve are created by compressing the flexible valve linkage, and as the amount of deflection cannot change instantaneously, neither can the acceleration. Mathematically, this is covered by saying that the accelaration d^2y/dx^2 must be a continuous function of x.

This rules out the possibility of making the curve by using two arcs of parabolas meeting in the center. A parabola has constant acceleration and the valve cannot be made to follow a path in which a positive acceleration suddenly becomes negative. However, the path with two parabolas would have the lowest maximum acceleration. In any other type of curve, the maximum acceleration would be greater than the average value, instead of being equal to it.

This leads to a fundamental theorem concerning valve motions. With a flexible valve linkage higher accelerations at the valve must be accepted than would occur with a rigid connecting system. There is a corollary: If a cam is designed on the assumption of a rigid system, the actual limiting speed will be lower than the theoretical.

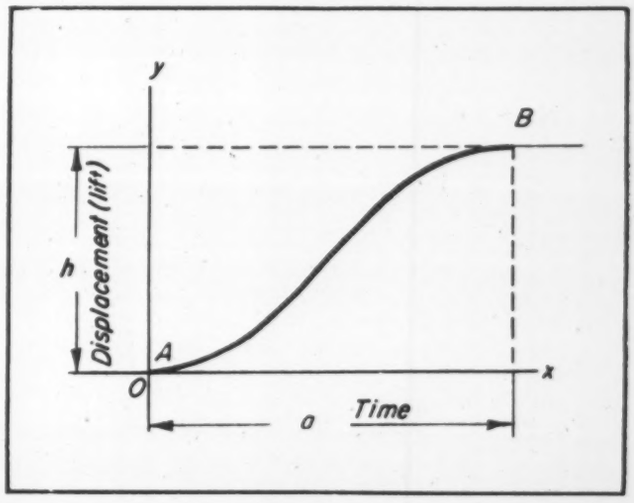
Thus, peak acceleration cannot be made the criterion for designing motion curves. Also, the maximum velocity cannot be so used. In *Fig.* 5 a straight line from A to B can be seen to have a lower maximum velocity than any curve of the type shown. Such a condition could be approached by having rapid curvature (high acceleration) at the beginning and end. The result, however, would give operating conditions approaching impact, and would be entirely impractical. Mathematically it may be said that, for various motion curves, the maximum velocity has a lower limit; but no true curve can be found which will reach this limit.

Under the limitations imposed it seems reasonable to select, as a motion curve, the function $y = f(x)$ which will make

$$J=\int_0^a \left(\frac{d^2y}{dx^2}\right)^2 dx \quad \ldots\ldots\ldots (5)$$

a minimum. Inasmuch as even a negative acceleration becomes positive when squared, the integral J gives a sort

Fig. 5—Typical problem in cam design is to establish suitable path from A to B so as to avoid shocks and jumps



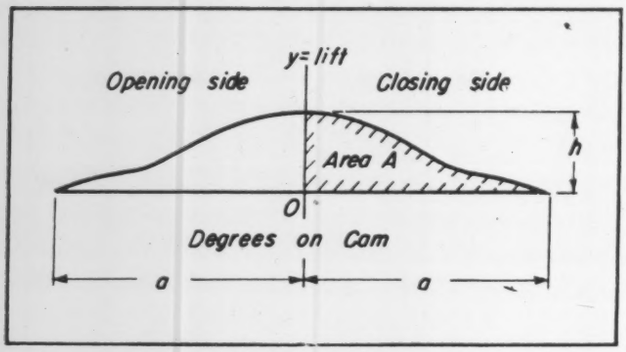


Fig. 6—Valve motion curve for lift and return, showing coordinates of length and height

of summation of all acceleration in a given curve $y = f(x)$. The use of acceleration squared will give relatively more weight to large accelerations than to small ones; this, too, seems a desirable property.

Equation 5 poses a simple problem in the calculus of variations, application of which leads to the general solution

$$y = C_0 + C_1x + C_2x^2 + C_3x^3 \quad \ldots\ldots (6)$$

which is a polynomial containing four arbitrary constants —just enough so that the displacement and velocity may be specified at each end of the motion curve.

Thus, for a set of conditions as in *Fig.* 5, a polynomial of the third degree or less will meet the requirements with a smaller "*J*-Value" or acceleration-squared integral, Equation 5, than any other curve, continuous or otherwise. The boundary conditions are: When $x = 0$, $y = 0$, and $dy/dx = 0$; also when $x = a$, $y = h$, and $dy/dx = 0$, so that Equation 6 becomes

$$y = \frac{3h\,x^2}{a^2} - \frac{2h\,x^3}{a^3} \quad \ldots\ldots (7)$$

which satisfies the foregoing boundary conditions.

BOUNDARY CONDITION LIMITATIONS: Unfortunately, an actual motion curve must meet additional boundary conditions as follows:

1. Acceleration at the start of actual lift must be zero. As the cam compresses the valve linkage, a point is reached at which the force just equals the force in the valve spring, and the valve is ready to move. Since the valve moves as soon as there is the slightest excess force, the motion cannot begin with a finite acceleration, but must begin with zero acceleration
2. Usually a curve that is ideal for acceleration purposes will not have enough area underneath it to assure maximum efficiency in passing gases through the valve. If a larger area under the curve is required, it can be obtained at the expense of slightly larger accelerations and *J*-values
3. As discussed in the foregoing, when the actual valve motion curve y has been selected the lift, velocity and acceleration of the cam profile are given by Equations 2, 3 and 4. At the point of greatest valve lift, $dy/dx = 0$. As valve cams are usually symmetrical about the center-line, it is necessary to have $dz/dx = 0$ at the same point. Equation 3 then requires that $d^3y/dx^3 = 0$ at the center of the cam
4. Frequently, in redesigning a valve cam for an existing engine, it is desired to improve the acceleration properties, and perhaps to change the "ramps" or lowest section, but otherwise to change the shape of the cam as little as possible. The designer's problem then is not to supply an entirely new lift curve of ideal acceleration properties, but rather to match the previous curve quite closely, with a new curve whose accelerations are functional, and low enough to be acceptable
5. Size of the actual cam, and the type of follower used, may limit the positive or negative acceleration values. The use of roller or spherical followers limits positive (outward) acceleration, while the diameter of the cam limits negative acceleration.

This makes a total of seven or eight boundary conditions. As Equation 6 contains only four adjustable constants, it is not adequate. Since there is no one best solution to the several requirements placed on the valve motion curve, a wide variety of mathematical functions might be used. However, it has been shown that polynomials of the third degree are the best solution to the simpler cam problems. When the number of boundary conditions exceeds four, it may reasonably be expected that polynomials will retain their advantage over other mathematical functions. This has been true in a number of specific cases. It is necessary to try various expressions to find which one meets the requirements and has a low *J*-value. In going through such a trial-and-error process, it is easier to predict the effect of a change in a polynomial than in such functions as cosines or exponentials.

TABLE II—**Lift and Derivatives from Equation 17**

$\frac{\theta}{a}$	$\frac{y}{h}$	$\frac{a}{h}\frac{dy}{d\theta}$	$\frac{a^2}{h}\frac{d^2y}{d\theta^2}$	$\frac{a^3}{h}\frac{d^3y}{d\theta^3}$	$\frac{a^4}{h}\frac{d^4y}{d\theta^4}$
0	1.0	0.0	—3.2812	0.0	0.0
0.1	0.983594	—0.32812	—3.2812	0.000	0.02
0.2	0.934375	—0.65623	—3.2805	0.030	1.03
0.3	0.852363	—0.98376	—3.2632	0.460	10.05
0.4	0.737809	—1.30511	—3.1246	2.873	43.99
0.5	0.592386	—1.59336	—2.5138	10.523	114.20
0.6	0.422778	—1.76976	—0.7599	25.692	180.03
0.7	0.247032	—1.68771	2.6749	41.705	98.23
0.8	0.098754	—1.20796	6.7978	33.708	—323.73
0.9	0.015681	—0.44042	7.4759	—30.588	—926.29
0.95	0.002119	—0.12471	4.7546	—77.959	—881.46
1.0	0.0	0.0	0.0	—105.000	0.0

SOLUTION WITH VARIABLE AREA: In *Fig.* 6 let the area *A* equal *bah*, where *b* represents the portion of circumscribed rectangle $a \times h$ which lies under the cam curve, on one side. Following are the boundary conditions, as already noted:

$$\text{When } \theta = 0,\ v = h,\ \frac{ay}{d\theta} = 0, \text{ and } \frac{d^3y}{d\theta^3} = 0 \quad \ldots\ldots (8)$$

and

$$\text{When } \theta = a,\ v = 0,\ \frac{dy}{d\theta} = 0, \text{ and } \frac{d\text{-}y}{d\theta^2} = 0 \quad \ldots\ldots (9)$$

Also

$$\int_0^a y\,d\theta = A = b\,a\,h \quad \ldots\ldots (10)$$

To meet these seven conditions would require an equation of the sixth degree. Such a solution would represent y on only one side in *Fig.* 6, as it would contain both odd and even powers. The same curve could be turned around and used for the other side. However, if only even powers of θ are used, Equation 8 is automatically satisfied, and the equation for y is of the eighth degree.

Both of these curves have been derived, and the symmetrical one shows lower J-values and accelerations, particularly at values of the area factor b above 0.5. The equation with even powers is:

$$y=h\left[1+C_2\left(\frac{\theta}{a}\right)^2+C_4\left(\frac{\theta}{a}\right)^4+C_6\left(\frac{\theta}{a}\right)^6+C_8\left(\frac{\theta}{a}\right)^8\right] \quad (11)$$

The values of C_2, C_4, C_6, and C_8 are found by applying Equations 9 and 10 to Equation 11, with the following results:

$$C_2=\frac{1}{16}(315b-192) \quad (12a)$$

$$C_4=\frac{1}{16}(-945b+480) \quad (12b)$$

$$C_6=\frac{1}{16}(945b-448) \quad (12c)$$

$$C_8=\frac{1}{16}(-315b+144) \quad (12d)$$

In attempting to obtain a reasonably close fit to the shape of an older cam, it may be necessary to compute as many as a dozen trial curves before a satisfactory result is achieved. This is most readily done by making tables giving the values of y and its derivatives at a series of points. The three variables are height h, length a and area factor b, *Fig.* 6. The first two can be treated by computing the tables in terms of y/h and θ/a. To facilitate getting trial curves with any value of area factor b, Equation 11 may be rewritten as follows:

$$\frac{y}{h}=Q_1+Q_2b \quad (13)$$

in which Q_1 denotes the "constant portion" and Q_2 the "b-portion" for each value of θ/a. As a sample of the use of this method, *Fig.* 7 shows the net motion y and its first four derivatives for area factor $b = 0.58$.

Equation 11 has been used for the actual valve motion in several cam designs. These were successful in producing smoother valve motion at high speeds than had ever been obtainable on earlier cams. However, experience disclosed two difficulties in the application of this solution:

1. In order to match the lift area of older cams, it is necessary for the area factor b to have values in the range 0.55 to 0.60. When this is done, the acceleration curve found from Equation 11 has a poor "saddle" in which the maximum negative acceleration occurs partway down on each side rather than at the center, *Fig.* 7
2. The cam surface has an awkward negative acceleration at the beginning and end of actual valve motion. In Equation 4 when $\theta = a$, $d^2y/d\theta^2 = 0$, thus $d^2z/d\theta^2$ at this point will depend on $d^4y/d\theta^4$, which has a large negative value. On small-diameter automotive camshafts, it may be impossible to have this much negative acceleration.

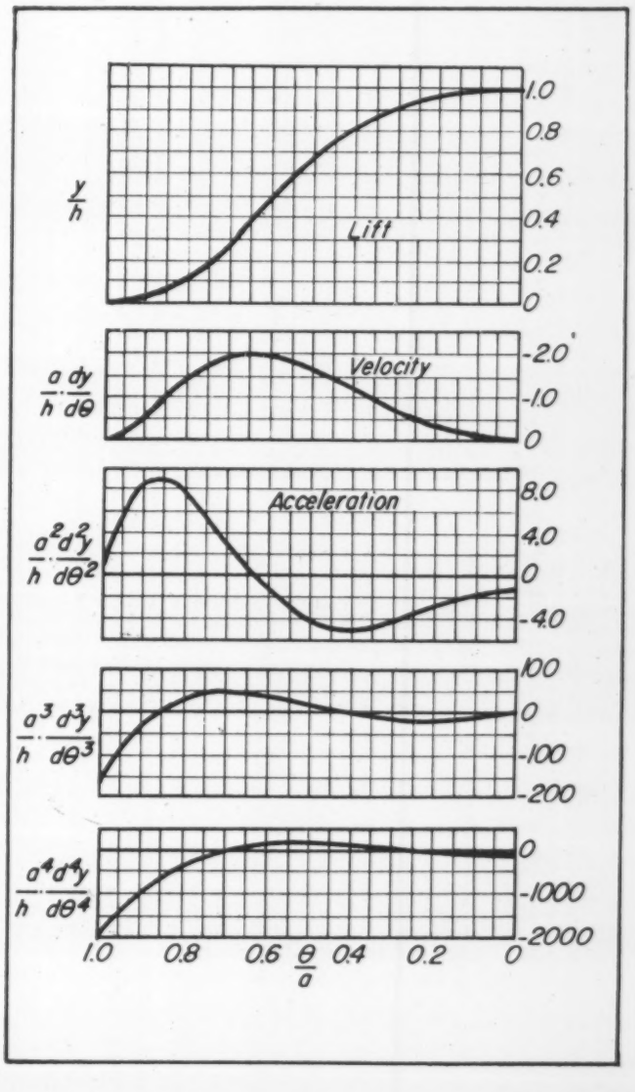
Solutions Using Various Powers: The preceding difficulties can be overcome by using slightly different polynomials. An examination of *Fig.* 7 shows that it is desirable to have a y-function whose acceleration is approximately constant in the center portion, and whose area factor is large. In Equation 11 the powers 2-4-6-8 were used, and the area was varied by changing the values of the coefficients. If the area is not specified, one less term is needed; however, a requirement should be added that

$$\text{When } \theta=a, \quad \frac{d^4y}{d\theta^4}=0 \quad (14)$$

From *Fig.* 7 it can be seen that the effect of Equation 14 will be merely that the initial rise of acceleration toward the positive maximum will be more nearly a straight line.

Consider now the effect of using equations with a constant term and combinations of powers such as 2-4-6-8, 2-6-8-10, 2-8-10-12, 2-10-12-14, etc. Retaining the power 2 will provide nearly constant acceleration in the center of the curve. Increasing the exponents of the other three

Fig. 7—Actual valve motion and its derivatives for variable-area solution with area factor b equal to 0.58



terms has the effect of moving the inflection point farther out, thus increasing the area under the curve. The problem may be solved in general terms by assuming

$$y=h\left[\,1+C_2\left(\frac{\theta}{a}\right)^2+C_p\left(\frac{\theta}{a}\right)^p+C_q\left(\frac{\theta}{a}\right)^{p+2}+C_r\left(\frac{\theta}{a}\right)^{p+4}\,\right] \quad \ldots\ldots (15)$$

The boundary conditions are expressed by Equations 9 and 14. After some algebra, the formulas for the constants are found to be:

$$C_2=\frac{-6p^2-24p}{6p^2-8p-8} \quad \ldots\ldots (16a)$$

$$C_p=\frac{p^3+7p^2+14p+8}{6p^2-8p-8} \quad \ldots\ldots (16b)$$

$$C_q=\frac{-2p^3-4p^2+16p}{6p^2-8p-8} \quad \ldots\ldots (16c)$$

$$C_r=\frac{p^3-3p^2+2p}{6p^2-8p-8} \quad \ldots\ldots (16d)$$

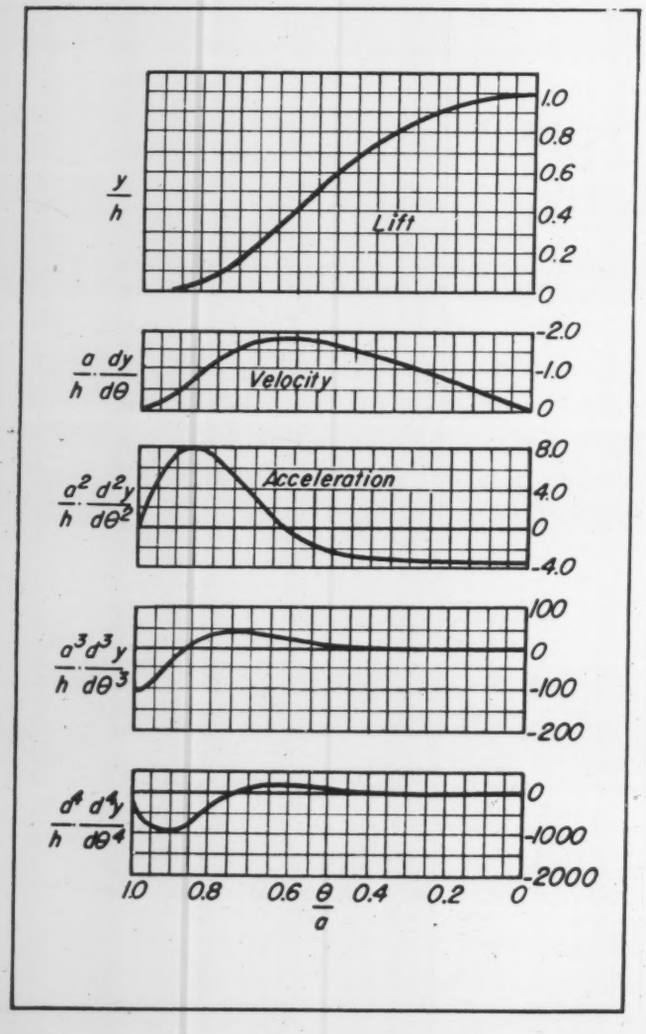
TABLE I gives a summary of the area factors, maximum velocities and accelerations, and *J*-values of various curves which can be used for actual valve motions. It is seen that the *J*-value tends to be a minimum when the area factor b is one-half.

Of the curves obtainable from Equation 15, the 2-10-12-14 is probably the best. It is well adapted for securing a close fit to older cam profiles. The 2-8-10-12 gives a rather small area, while the 2-12-14-16 involves more severe accelerations. TABLE II gives the values of y and its derivatives for the 2-10-12-14 equation, which is (with $p = 10$):

$$y=\frac{h}{64}\left[\,64-105\left(\frac{\theta}{a}\right)^2+231\left(\frac{\theta}{a}\right)^{10}-280\left(\frac{\theta}{a}\right)^{12}+90\left(\frac{\theta}{a}\right)^{14}\,\right] \quad \ldots\ldots (17)$$

The shape of the curves is shown in *Fig.* 8.

Fig. 8—Actual valve motion and derivatives for solution with powers 2-10-12-14, area factor being 0.54



The coefficients in Equations 11 and 15 have been adjusted to provide zero velocity for the actual valve motion at the instants of opening and closing. Equation 2 will then give the cam profile necessary to cause such a valve motion to take place at the assumed speed. Referring to *Fig.* 1, the cam profile will be thus computed between points *B* and *D*. The end section *AFG* can be made in any convenient way which fits smoothly with the bottom circle at *A* and the cam profile at *G*. The section *FG* compresses the valve linkage to equal the valve spring force, the amount of compression being given by the first term of Equation 2. If the cam is to operate with a constant amount of "lash" or clearance, this is used as the vertical height from *A* to *F*.

It is impossible to correct cam design fully for variable clearance. If a cam is run with a clearance different from the designed value, the valve motion will begin earlier or later than it should, and the quality of the results will deteriorate.

A solution is to make use of self-adjusting tappets or pushrods, which have recently been developed. These are capable of lengthening or shortening as circumstances require. Normally, zero clearance is maintained, but if a constant operating clearance is desired, it can be provided by building in a spring-loaded element of adjustable stroke. As these self-adjusting mechanisms automatically correct for all variations, the use of them in connection with a functionally-designed cam assures a good valve motion. It is probably not worthwhile to attempt a functional cam design unless self-adjusting mechanism is used to hold the clearances constant.

CALCULATON: Usual practice is to compute values of the cam lift, z, from Equation 2 at intervals of one degree for automotive cams, or one-quarter degree for aircraft (radial) cams. This is the most tedious part of the work. It may be carried out (a) by expanding the standard tables, such as TABLE II, computing the derivatives at one-degree intervals for the desired value of length a; or (b) by substituting the equation for net motion y (such as Equation 17 in Equation 2) with numerical values. This gives the desired cam lift, z, as a polynomial in powers of θ.

By either method, the polynomial expressions must be evaluated at a large number of points. In such work it

(*Concluded on Page* 184)

MACHINE DESIGN — Editorial

Processing Takes the Spotlight

Greatly increased production, absolutely essential during the war, is also a vital factor in relation to current peacetime industry. The major difference, however, concerns costs and prices. Little consideration could be given to the cost of producing machinery and equipment following Pearl Harbor; now, the situation is completely reversed. Authorities in the field of economics seem to agree that with wages rising at a much faster rate than productivity, the increase in prices which necessarily results may sooner or later create a dangerous condition of buyer resistance. As far as consumer goods in particular are concerned, prices could conceivably reach a level at which it would be utterly impossible for the average user to make the purchases he had planned, and on the anticipation of which manufacturers' schedules had been based.

Because many forces are at work which limit the capacity of the individual to produce, as brought out recently by L. E. Osborne, vice president of Westinghouse Electric Corporation, individual productivity cannot be depended upon to help solve the problem by turning out more goods at lower cost. Consequently it becomes even more necessary that the designer of machines give intense consideration to increased mechanization of processes and to automatic operation of machines, thus reducing to the limit the cost of labor involved in production.

Another important step that offers the designer many favorable opportunities for keeping at a minimum the cost of manufacture is the utilization of the most advantageous production methods. Considerable reduction in cost usually can be effected if, in the design of the component parts that go to make up a specific machine, the question of economical production is given proportionate consideration with the functioning of each part.

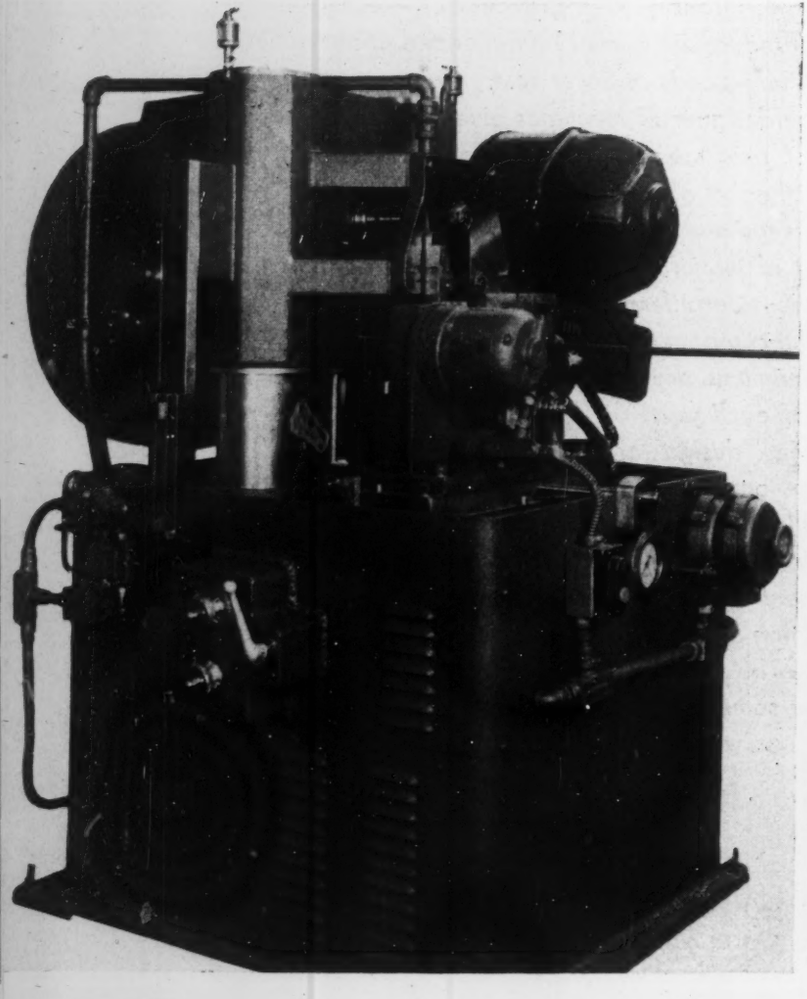
Achievement of practical production design—or redesign—of this nature necessarily entails thorough knowledge, on the part of the designer, of the various basic methods of fabrication as well as of the new methods that are being increasingly employed. That designers of all types of machines are anxious to possess such information is amply evident from the acceptance of MACHINE DESIGN's series of articles on production processes and their effect on design. Members of the design profession are to be complimented on their ambition to ease production headaches and at the same time facilitate the continued manufacture of machines at reasonable cost, on which the national economy so largely depends.

L. E. Jerry

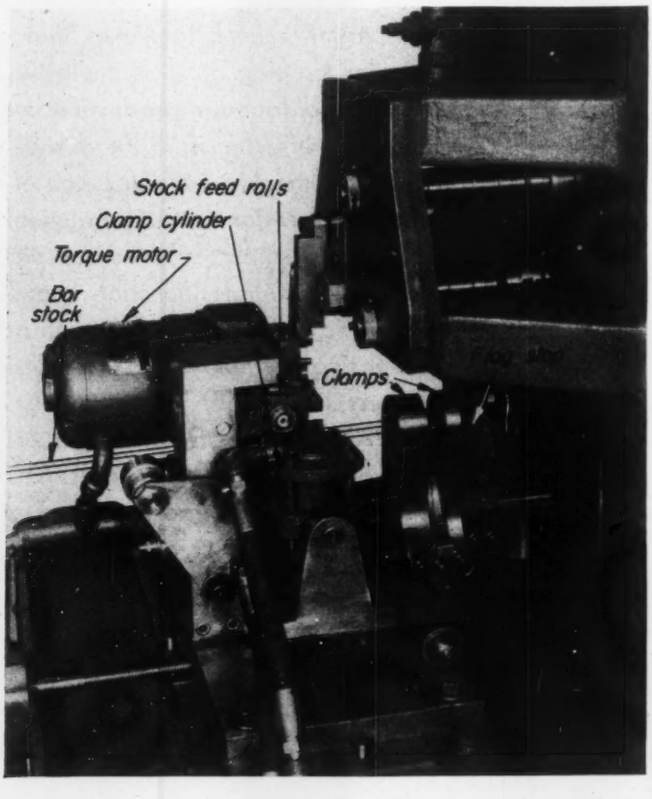
DESIGNS OF THE MONTH

Automatic Miller Feeds, Mills and Cuts Off Shaped Bar

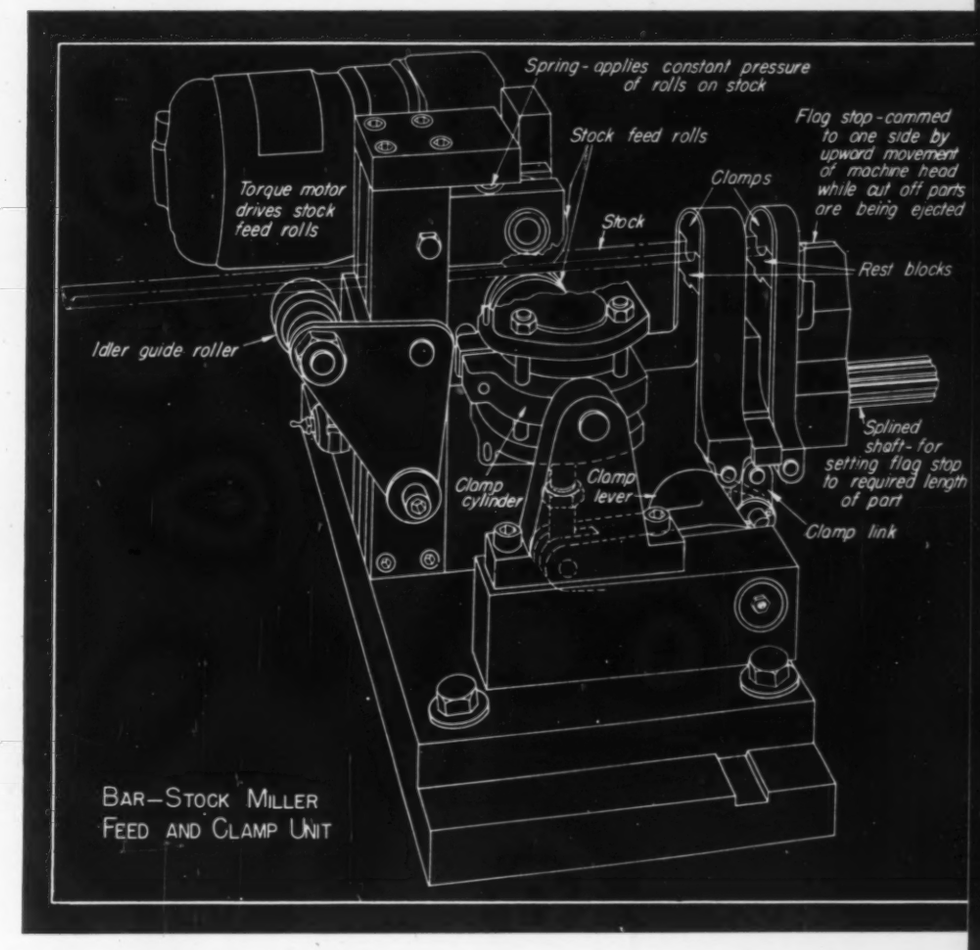
THIS automatic bar-stock milling machine feeds and clamps a bar of almost any cross section, mills it to some specified shape and cuts it off. The machine has a bed of welded construction from which protrude two round steel posts. A three-spindle head, actuated by a hydraulic cylinder mounted in the bed, moves up and down on these posts. Its cycle is continuous and includes rapid advance down, feed of forming cutters, jump, feed of cutoff saw, reverse and rapid return up. This cycle is controlled by dogs contacting a plunger of the hydraulic panel. Drive motor of the spindle is mounted on a rocker arm at the side of the head and provides counterbalance for the head. Drive from the motor to the head is through V-belts to one spindle and from that spindle to the other two by means of gears inside the head. One of the lower spindles is mounted in an eccentric quill for adjusting the center distance between it and the other lower spindle. Gear drive between these spindles is through an idler journaled in a swinging yoke to accommodate this adjustable center distance. Immediately in front of the head is the stock feeding and clamping mechanism which is mounted on the bed with adjustment provided in cross and longitudinal directions.



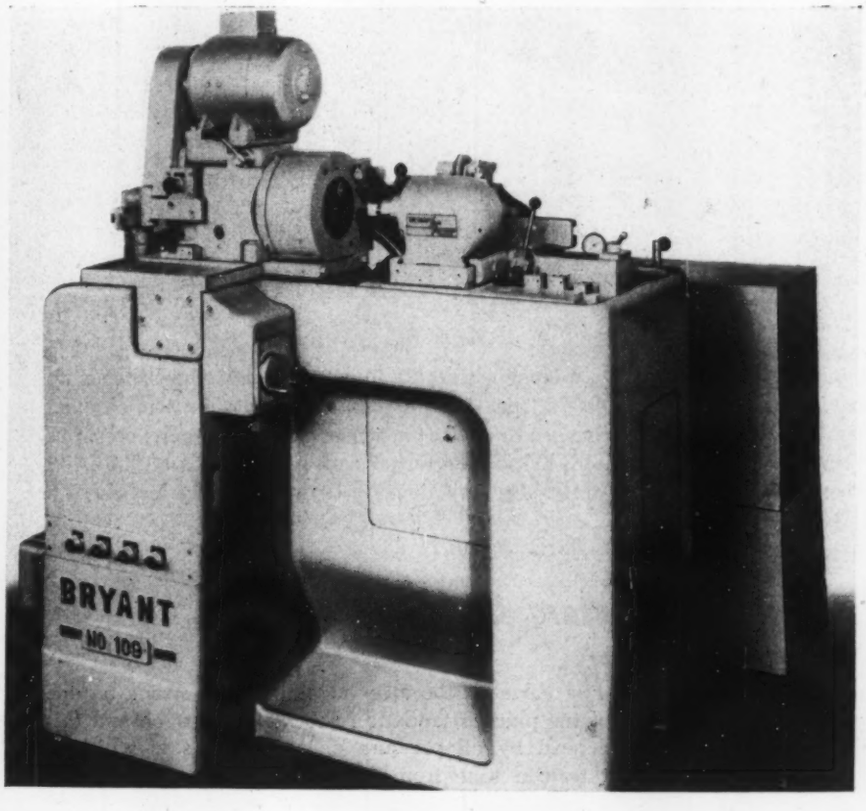
In the stock-feeding and clamping unit, shown in the three-dimensional drawing (top, next page), a torque motor drives the feed rolls at uniform speed. When the stock reaches the flag stop the rolls maintain their



grip on it, and the motor, still energized, presses the stock firmly against the stop. The clamps, which hold the stock while it is being milled, are operated hydraulically. All functions of stock-feeding and clamping unit are controlled and timed by dogs on the bar extending down from the head, except the oscillation of the flag stop. A link between it and the head swings it from the stop position to the ejecting position. Manufacturer: Kent-Owens Machine Co., Toledo 10, O.

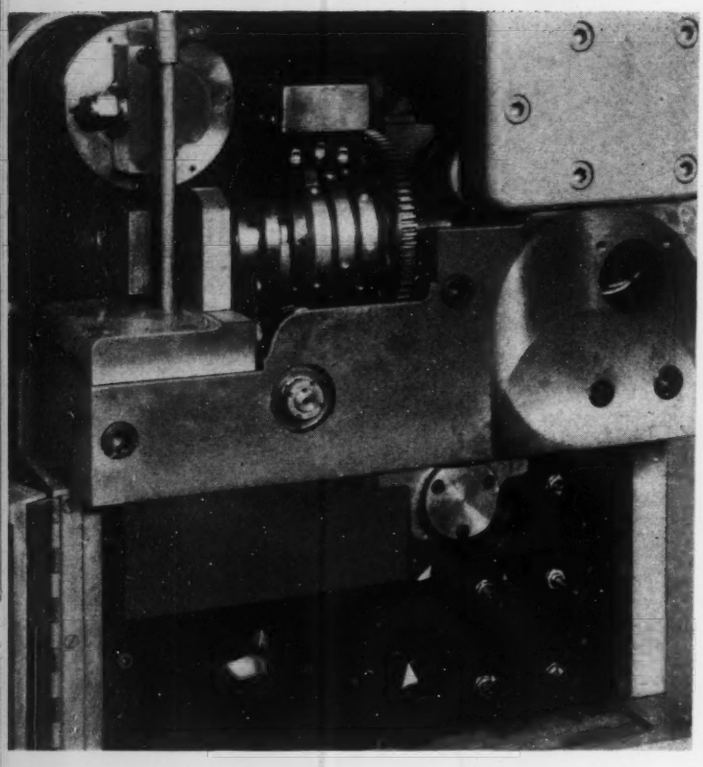


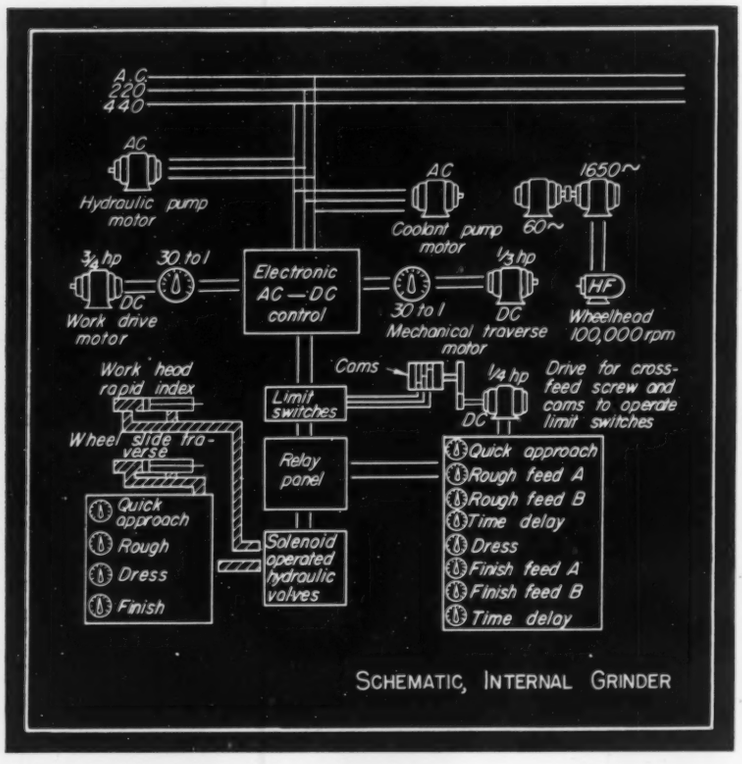
Internal Grinder Employs Axial Ball Bearings on Slides



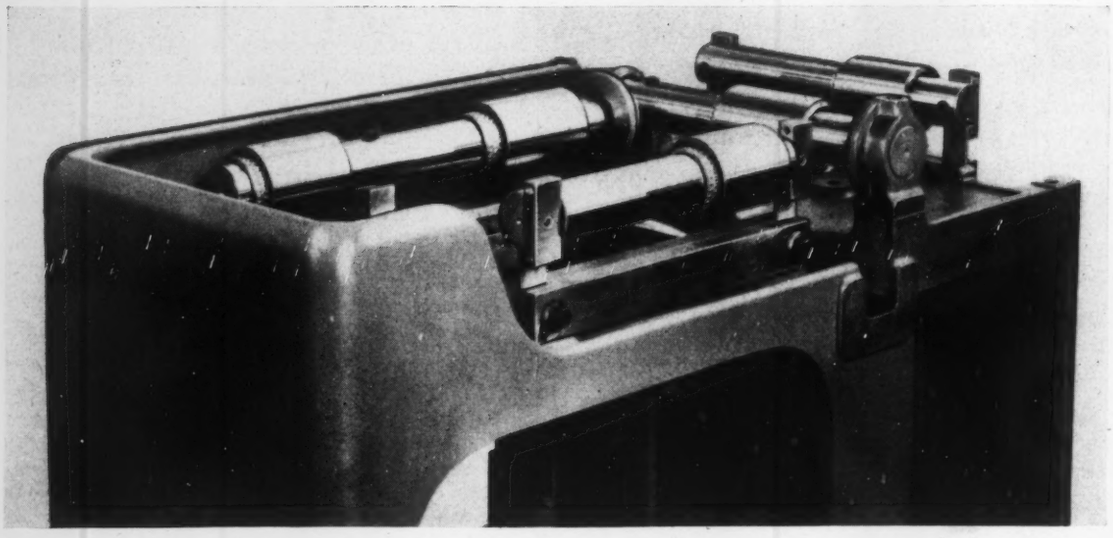
NEW automatic internal grinder uses preloaded axial ball bearings on both its longitudinal and cross slides, as shown in the photograph (center, next page). This arrangement insures freedom of slide motion and transmittal of grinding loads to the machine base. Both slides are grease-packed and sealed at the factory.

By providing dc motors to supply driving power to the cross feed and the work-drive spindle, an infinite number of feeds and speeds are available. The feed controls (top left, next page), consist of three adjustable cams and five rheostats to provide extreme flexibility of adjustment and ease of setup. The cams operate limit switches to control the rate of feed by the dc motor drive. These cams are easily set to increase or decrease the rate of feed at any position in the grinding cycle. Each of the rheostats provide independent control of the various positions of the cycle. One controls fast approach for rough grinding, two provide additional speed rates for rough grinding, and the last two control rates





SCHEMATIC, INTERNAL GRINDER



of speed during finish grinding. The main wheel slide traverse is operated hydraulically and four individual throttles allow the preselection of the best traverse speed for quick approach, rough grinding wheel trueing and finish grinding. The machine uses a new direct-mounted high-frequency wheelhead unit with which wheel speeds up to 100,000 rpm can be attained to assure the efficient surface speeds necessary when grinding small bores. A balanced, belt-driven wheelhead, gives speeds of 200-2400 rpm. Mfr: Bryant Chucking Grinder Co., Springfield, Vt.

Diesel Has Novel Oil-Pressure Control

OIL pressure control in this new diesel engine is unusual in that the pressure at the main bearings and also in the rest of the system is regulated by the pressure at the center main. This is accomplished by a plunger-type throttling valve on the oil pump intake. A spring on one side of the plunger tends to force the valve open and this is balanced by oil pressure on the other side which is brought by a tube from the center main. Thus, when

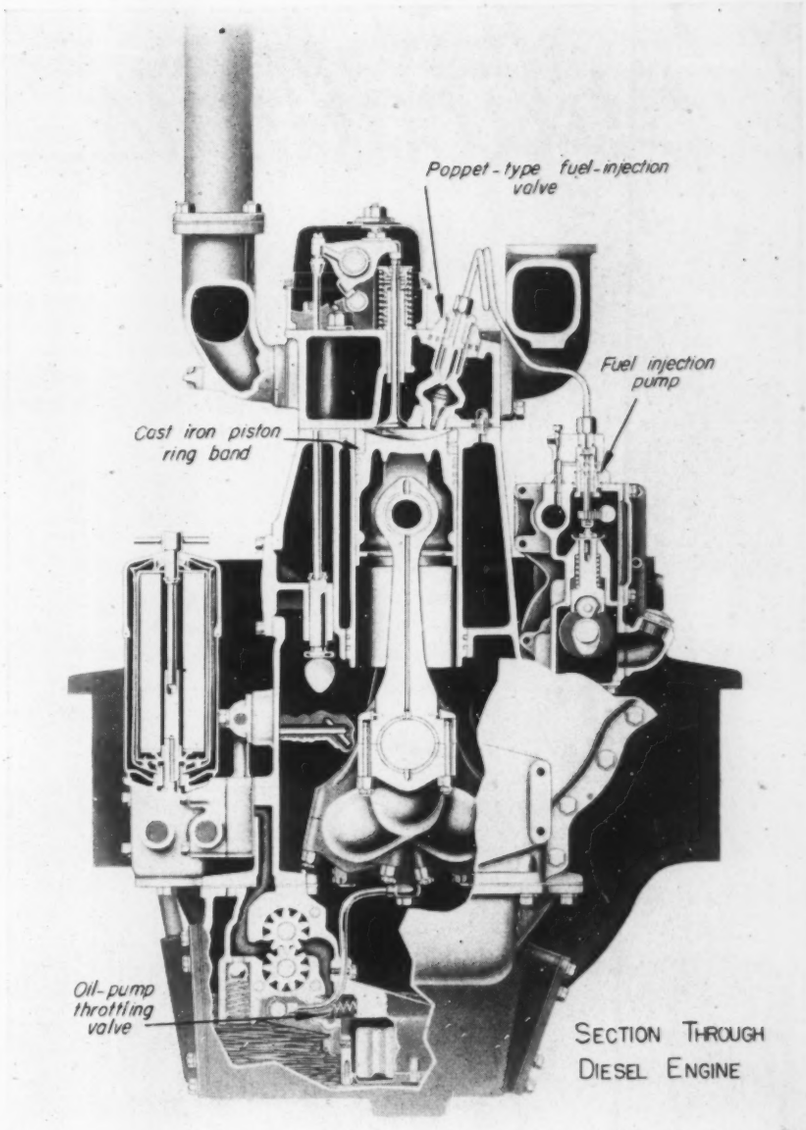
starting, the full output of the pump, limited to 90 psi by a safety valve in the pump, is available to push stiff, cold oil through the lines to the bearings. When the pressure at the center main reaches the correct point, it causes the plunger to close partially, holding the pump output at the correct amount. System pressure is maintained automatically thereafter, regardless of engine speed variations. This system obviates the high-velocity jet of oil from the conventional oil-pump bypass which causes undesirable turbulence in the oil pan.

Of 4½-inch bore and 5½-inch stroke, the engine has a piston displacement of 525 cubic inches. Its full-load speed range is 1000 to 1800 rpm and maximum output with full equipment, including radiator fan, is 105 hp. Several features contribute to good volumetric efficiency. As shown in the sectional view, individual ports are used with intake and exhaust manifolds on opposite sides of the head, allowing smooth, streamline flow of air and exhaust gases. In addition, the valves are of generous diameter with high lift.

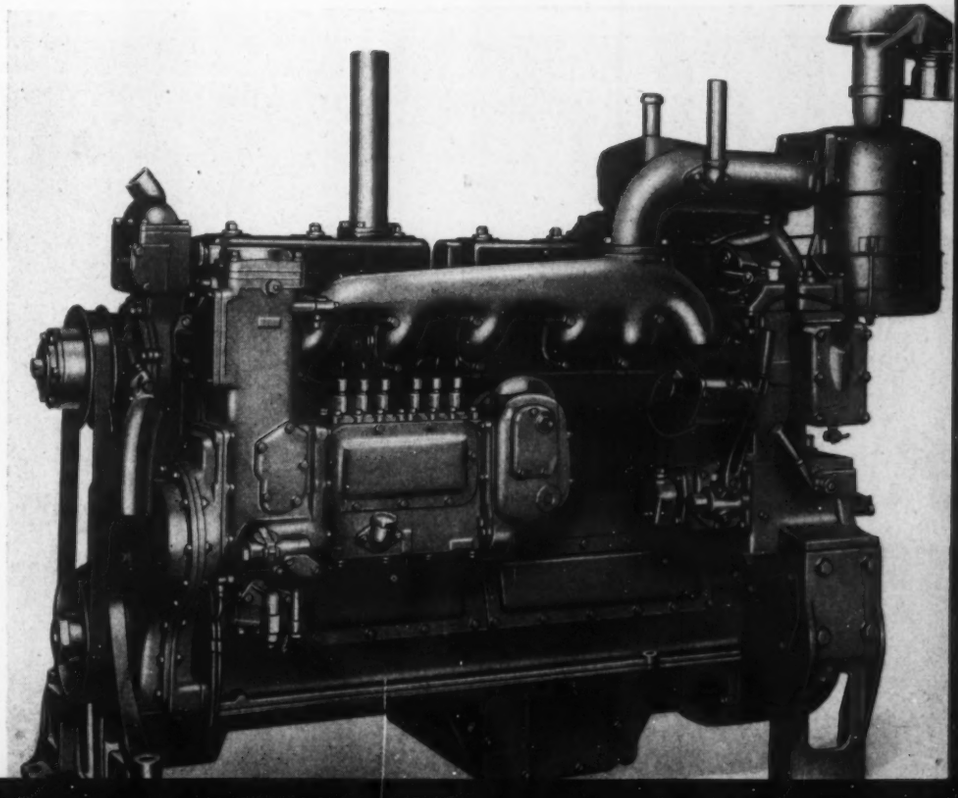
Valves Are Capsule-Enclosed

Fuel-injection valves, pressure operated, are of the poppet type, with seat and spring enclosed in a metal capsule which is replaceable as a unit. Ends of the capsule are rolled over with openings provided at each end for fuel passage. The single-orifice spray nozzle projects from the lower end of the capsule into the precombustion chamber.

Pistons are aluminum alloy and of composite construction with the top-ring groove cut in a cast-iron band. This band, held in place by a threaded aluminum ring, provides a distortion and wear-resisting support for the important top piston ring. Pistons are oil cooled by jets in the upper end of the rifle-drilled connecting rods and are held within close weight limits, as are the connecting rods which are also balanced end for end. All crankshaft bearing surfaces are induction hardened and superfinished. Crankshafts and other major rotating parts are dynamically balanced. Main bearing shells and the connecting-rod large-end bearings are solid aluminum alloy, thus eliminating steel backing and its accompanying bending troubles. The cast iron, wet-type cylinder liners are machined all over for uniformity and induction hardened on inner surfaces. Manufacturer: Caterpillar Tractor Co., Peoria 8, Ill.



SECTION THROUGH DIESEL ENGINE

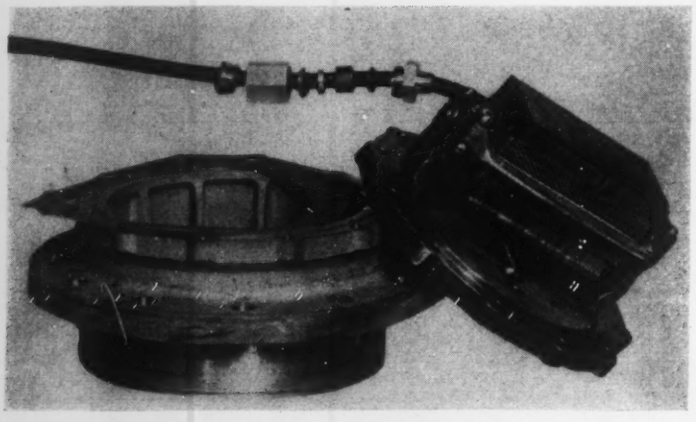


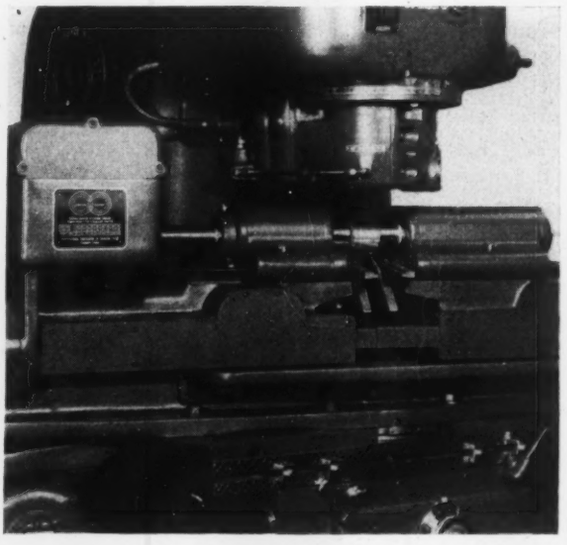
Applications

of engineering parts, materials and processes

Detector Uses Nickel Magnetostriction

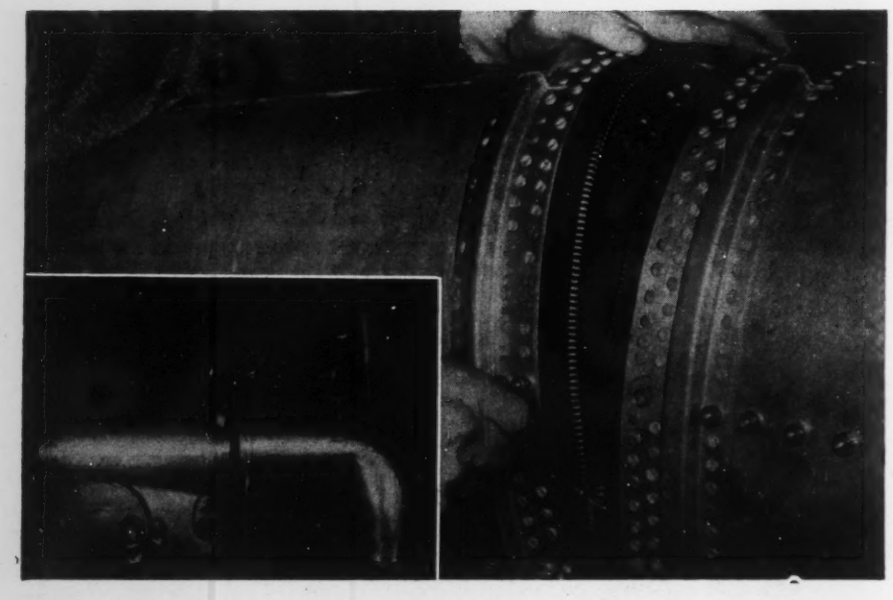
HIGH MAGNETOSTRICTION coefficient of nickel makes possible the Fathometer, a device used to determine ocean depth. The transmitter of this Submarine Signal Co. development, below, passes a strong magnetic field through stacked nickel laminations. Resultant vibrations produced by the magnetostriction travel as sound waves to ocean bottom. Reflected sound is used to measure water depth which is indicated on the instrument dial. So sensitive is the instrument that it can be used to determine differences in water density.





Shaves Rotors at High Speed

RAPID MACHINING to close tolerance of electric-motor rotor laminations is accomplished in the Red Ring Roto Shaver, above. Similar to a milling machine, the "shaver" utilizes a fine-pitch, high-precision cylindrical cutter operating at high speed. Axis of the cutter is, however, at a small angle with the work axis rather than parallel or normal to it. Rotor simultaneously rotates and traverses under the cutter head.



Zipper Serves as Pressure Seal

SUPERCHARGER AIRDUCTS on the Army Air Force's Republic XF-12 are joined into airtight units by use of the B. F. Goodrich pressure-sealing zipper as shown at the left. Twelve of the zipper units are required for the plane, three for each of the supercharger ducts to the four 28-cylinder engines. The system is thus rendered airtight, while at the same time being flexible and immune to vibration fatigue.

Equivalent Spur and Helical Gears

By Carl A. Johnson
Perkins Machine & Gear Co.
Springfield, Mass.

IN redesigning machines a simple and effective improvement is the replacement of spur gears by helical gears. Such replacement need involve no other design changes if advantage is taken of the proportions given in the accompanying table. This permits the designer to incorporate the acknowledged superiority of helical gears without compromising other features of the design.

In cases where exact ratios must be held due to timing requirements or space limitations, the number of teeth and the pitch diameters of the helical gears must be the same as the spur gears which they replace. Under these circumstances the diametral pitch of the helical gear in the plane of rotation will be exactly the same as that of the spur gear which it replaces. For the helical gear,

$$P_d = P_{nd} \cos \psi$$

where P_d = diametral pitch in the plane of rotation, P_{nd} = normal diametral pitch, and ψ = helix angle.

Since standard spur gear hobs are usually available, the normal diametral pitch should be selected to use these hobs if possible. The table gives from one to seven choices of standard, normal diametral pitch and helix angle which will produce a helical gear with a standard diametral pitch in the plane of rotation the same as that of the spur gear replaced.

P_d Spur Gear	Normal Diametrical Pitch, P_{nd}, & Helix Angle, ψ, of Helical Gear				
1	1¼ 36°52′12″				
1¼	1½ 33°33′26″	1¾ 44°24′55″			
1½	1¾ 31° 0′10″	2 41°24′35″			
1¾	2 28°57′18″	2¼ 38°56′33″			
2	2¼ 27°15′58″	2½ 36°52′12″	2¾ 43°20′30″		
2¼	2½ 25°50′31″	2¾ 35°5′48″	3 41°24′35″		
2½	2¾ 24°37′12″	3 33°33′26″	3½ 44°24′55″		
2¾	3 23°33′23″	3½ 38°12′48″			
3	3½ 31° 0′10″	4 41°24′35″			
3½	4 28°57′18″				
4	5 36°52′12″				
5	6 33°33′26″	7 44°24′55″			
6	7 31° 0′10″	8 41°24′35″			
7	8 28°57′18″	9 38°56′33″			
8	9 27°15′58″	10 36°52′12″	11 43°20′30″		
9	10 25°50′31″	11 35° 5′48″	12 41°24′35″		
10	11 24°37′12″	12 33°33′26″	13 39°42′54″	14 44°24′55″	
11	12 23°33′23″	13 32°12′15″	14 38°12′48″	15 42°50′ 0″	
12	13 22°37′12″	14 31° 0′10″	15 36°52′12″	16 41°24′35″	
13	14 21°47′12″	15 29°55′35″	16 35°39′33″	17 40° 7′ 9″	18 43°45′42″
14	15 21° 2′22″	16 28°57′18″	17 34°33′37″	18 38°56′33″	19 42°32′13″
15	16 20°21′51″	17 28° 4′21″	18 33°33′26″	19 37°51′49″	20 41°24′35″

P_d Spur Gear	Normal Diametrical Pitch, P_{nd}, & Helix Angle, ψ, of Helical Gear						
16	17 19°45′ 0″	18 27°15′58″	19 32°38′13″	20 36°52′12″	22 43°20′30″		
17	18 19°11′17″	19 26°31′31″	20 31°47′18″	22 39°24′ 2″	24 44°54′ 2″		
18	19 18°40′18″	20 25°50′31″	22 35° 5′48″	24 41°24′35″			
19	20 18°11′42″	22 30°16′22″	24 37°39′30″	26 43° 2′57″			
20	22 24°37′12″	24 33°33′26″	26 39°42′54″	28 44°24′55″			
22	24 23°33′23″	26 32°12′15″	28 38°12′48″	30 42°50′ 0″			
24	26 22°37′12″	28 31° 0′10″	30 36°52′12″	32 41°24′35″			
26	28 21°47′12″	30 29°55′35″	32 35°39′33″	34 40° 7′ 9″	36 43°45′42″		
28	30 21° 2′22″	32 28°57′18″	34 34°33′37″	36 38°56′33″	38 42°32′13″		
30	32 20°21′51″	34 28° 4′21″	36 33°33′26″	38 37°51′49″	40 41°24′35″	42 44°24′55″	
32	34 19°45′ 0″	36 27°15′58″	38 32°38′13″	40 36°52′12″	42 40°22′ 3″	44 43°20′30″	
34	36 19°11′17″	38 26°31′31″	40 31°47′18″	42 35°57′ 2″	44 39°24′ 2″	46 42°20′33″	48 44°54′ 2″
36	38 18°40′18″	40 25°50′31″	42 31° 0′10″	44 35° 5′48″	46 38°30′ 0″	48 41°24′35″	50 43°56′44″
38	40 18°11′42″	42 25°12′32″	44 30°16′22″	46 34°18′ 4″	48 37°39′30″	50 40°32′ 9″	
40	42 17°45′10″	44 24°37′12″	46 29°35′31″	48 33°33′26″	50 36°52′12″	56 44°24′55″	
42	44 17°20′29″	46 24° 4′14″	48 28°57′18″	50 32°51′36″	56 41°24′35″		
44	46 16°57′27″	48 23°33′23″	50 28°21′27″	56 38°12′48″	60 42°50′ 0″		
46	48 16°35′52″	50 23° 4′26″	56 34°46′19″	60 39°56′40″	64 44° 2′55″		
48	50 16°15′37″	56 31° 0′10″	60 36°52′12″	64 41°24′35″			
50	56 26°45′56″	60 33°33′26″	64 38°37′29″				
56	60 21° 2′22″	64 28°57′18″					
60	64 20°21′51″						

Assets to a Bookcase

Machine Design

By Vladimir L. Maleev, professor of mechanical engineering, Oklahoma Agricultural and Mechanical College; published by the International Textbook Co., Scranton, Pa; 590 pages, 6 by 9 inches, clothbound; available through MACHINE DESIGN, *$5.00 postpaid.*

To the original edition of this book, originally published in 1939, has been added a comprehensive chapter on power screws. In addition the volume has been largely revised and brought up to date.

Believing that stress analysis is the heart of machine design, the author has made an excellent attempt to present all pertinent information on this subject in one section of his book. This he does by grouping them under the headings: Stresses in Machine Parts, Properties of Materials, and Machine Design Calculations. While two of these subjects are not subject to rapid change, the third—properties of materials—is. Advancement in metallurgy and chemistry is moving apace. The author has therefore taken care to cover this aspect as carefully as is appropriate to a book of his scope, and to bring it completely up to date in this revision.

The chapter on power screws discusses in some detail the types of screw threads that may be used in machines, and their computations. Covered are: Square, buttress, acme and ball type threads. The discussion gives typical design computations for determining stresses and bearing load, and thread shapes and sizes. The presentation is careful and detailed and well illustrated with curves and examples.

□ □ □

Mathematical Methods in Engineering

By Theodore V. Karman, director, Guggenheim Aeronautics Laboratory, California Institute of Technology, and Maurice A. Biot, assistant professor of mechanics, Columbia University; published by McGraw-Hill Book Co. Inc., New York; 505 pages, 5½ by 8½ inches, clothbound; available through MACHINE DESIGN, *$4.50 postpaid.*

Intended for use as an aid to engineers in applying mathematics to practical problems, this book should be of great use to the general designer. It requires only the knowledge of algebra, analytical geometry and basic calculus and, building upon them, clearly illustrates the methods of handling such problems as vibration, structures, and dynamics.

The book is divided into few sections. Apart from the first two chapters which cover differential equations and Bessel functions, it discusses such typical problems as: Oscillations, dynamics, transients and periodic phenomena; and typical problems involving series.

In writing the volume the authors have taken the second of two methods of presentation. Since they are concerned with engineering problems, they have avoided the simpler and more obvious device of covering their subject by branches of mathematics. Rather, they have grouped engineering problems into types of similar characteristics, and have placed the mathematical approach and treatment thereunder.

□ □ □

The Inventor's Magna Charta

By Edwin Hopkins, self published at 255 W. 43 St., New York 18, 4½ by 6⅜ inches, paperbound; available through MACHINE DESIGN, *$3.00 postpaid.*

The patent law is not, contrary to general belief, intended only to protect the inventor. It is, rather, a device to aid the public by enticing from inventors their secrets in return for a period of monopoly in which the development may be exploited. While this inheritance from common law has served its purpose well in the past, there is excellent reason to believe that modification is overdue.

The author of this book has studied the patent situation at some length and offers suggestions intended to cure a number of the ills. He recommends, for example, that the government be responsible for enforcing patents as it is for enforcing other laws, and that the "claims" system be modified and improved. While he tends to lean toward the left in some of his thinking, there is much of his argument with which the staunchest reactionary will agree. Such faults are described as the injustice done the financially weak inventor, the negative interpretations often given by the patent office, and the actual lack of protection inherent in patents. An exceedingly difficult subject is handled in such a manner as to provoke considerable thought and comment.

Designers concerned with sheet or tubular parts having regular or irregular bends will find the book "The Cold Bending of Metals" of much interest. Knowledge of the bending technique as well as its limitations will prove of considerable value in effecting satisfactory production design. The book describes in detail the various methods of cold forming, gives tabulated data on tolerances and radius limits. It is well illustrated with photographs and drawings. The book is paperbound, measures 8¾ by 11¼ inches, and is available from Wallace Supplies Manufacturing Co., publishers, 1300 Diversey Parkway, Chicago 14, at $2.50.

MACHINE DESIGN'S

MATERIALS WORK SHEET

FILING NUMBER
28.00

Carbon and Graphite

MATERIALS COVERED

Carbon, graphite, carbon-graphite, metal-graphite, impervious carbon, impervious graphite, porous carbon, and porous graphite.

FORMS AVAILABLE

Cylinders, squares, slabs, pipes, tubes, brick, beams, blocks, plates, tile, rods, and molded parts produced to specification.

PROPERTIES

(average ranges)

Apparent Density	Weight (lb/cu ft)	Tensile Strength (psi)	Compressive Strength (psi)	Transverse Strength (psi)	Elastic Modulus (psi)	Specific Resistance (ohms/in.^{2})	Thermal Expansion K°	Thermal Conductivity (Btu/hr/sq ft/deg F/ft)
CARBON IN STANDARD FORMS (cylinders, squares, slabs, pipes, tubes and brick)								
1.525-1.57	95-97.8	400-840	1910-4100	790-1670	430,000-940,000	0.0013-0.0026	12-15	4-6
GRAPHITE IN STANDARD FORMS (cylinders, squares, slabs, pipes, tubes and brick)								
1.53-1.56	95.3-97.3	440-760	3050-3420	1490-1810	670,000-880,000	0.00036-0.00040	5-12	70-94
POROUS CARBON IN STANDARD FORMS (plates, open and blind-end tubes and rods)								
1.03-1.05	68-69	80-190	300-900	160-600	>120,000	0.0057-0.0080	27	1-1.5
POROUS GRAPHITE IN STANDARD FORMS (plates, open and blind-end tubes and rods)								
1.03-1.05	68-69	50-110	270-520	140-250	....	0.0012-0.0020	21-22	20-50
CARBON AND GRAPHITE MOLDED PARTS								
1.4-2.2	87-137	400-3500	2000-25000	....	1,330,000-2,420,000	....	10-60	....

° Coefficient of Thermal Expansion per degree, to temperature of t degrees, F = [K+0.0039t(deg F)] 10^{-7}. Note: In general, strength of the materials (psi) decreases with increases in section area.

MACHINE DESIGN is pleased to acknowledge the collaboration of the following companies in this presentation: Morganite Brush Co., National Carbon Co. Inc., The Ohio Carbon Co., Pure Carbon Co., and The United States Graphite Co.

CHARACTERISTICS

Carbon as an engineering material generally is produced from a coke or petroleum-coke base by pulverizing and hot mixing with suitable hydrocarbon bonding materials, hot extruding or molding to shape and then gas baking for long periods of time. Two forms of graphite are available, one natural, the other manufactured, the former being mined in the natural state. The latter is produced from carbon by impregnating the carbon with hydrocarbon materials in an autoclave and then subjecting it to a long-time, high-heat treatment in an electric direct-resistance furnace, the material itself serving as the heating element.

Carbon is a dull, light-gray, extremely hard, brittle and abrasive material of somewhat porous structure and no self-lubricating properties. It is chemically inert in practically all but strong oxidizing conditions. Graphite, on the other hand, is a jet black, glossy slick, nonabrasive material, also of somewhat porous structure, but with unexcelled self-lubricating properties. It is more resistant to oxidizing conditions at high temperatures than carbon.

Carbon-graphite may be produced either by partially graphitizing carbon, or by mixing pulverized natural graphite with a suitable hydrocarbon bonding material, hot extruding or molding to shape and baking. The metal-impregnated graphites are used where improved strength, wear resistance, or electrical conductivity (copper-impregnated) are design requirements.

Impervious carbons and graphites, used for parts which must be gas or liquid-tight, are produced by impregnating the material with suitable impregnants in an autoclave. What impregnants are used depends on service conditions, such as temperatures, material to be handled, etc. Porous carbon and graphite materials are produced in a range of pore sizes from about 33 to 190 microns diameter. Porous graphite is more resistant to oxidation than ordinary graphite.

Both carbon and graphite have extremely low coefficients of expansion, ability to withstand high temperatures (excepting where strong oxidizing atmospheres are present) and thermal shock without warpage or cracking, exceptional resistance to chemicals, and good electrical conductivity where needed (graphite excels). Carbon has a low rate of heat transfer, while that of graphite is high. In fact, since surface films do not form on graphite, its long-time rate is higher than that of copper.

APPLICATIONS

Carbon and graphite of a variety of grades are employed for many machine parts. Bearings and bushings of graphite or carbon-graphite are well suited for applications where oil or grease lubrication cannot be used or where resistance to corrosion is essential. These bearings are self-lubricating and can be finished to close tolerances. Packing rings of carbon, graphite or metal-graphite composition are manufactured for steam turbine and turbine blower packing, nonlubricated stuffing box packing, piston pressure seal rings, dryer roll steam seals and thrust collars, etc. These rings can be produced in almost any desired shape or size either annular or segmented, with cross section and type of joint adapted to the specific application. Entire pumps and valves of carbon and graphite are made for handling chemicals. Other typical parts are: Ringless pistons, dash-pot plungers, nozzles and orifices, sliding contacts and parts for liquid and gas meters, inserts in metal-bearing surfaces and brake shoes, pump parts requiring self-lubrication or resistance to corrosion, erosion-resisting boiler flue-gas scrubber plates and baffles, and a wide variety of bolts, nuts, plates, etc., for equipment where thermal, corrosion and lubrication problems are encountered.

Carbon and graphite tubes and fittings are used in the construction of many types of heat-exchange units in the chemical industries because of their excellent corrosion resistance and resistance to damage from thermal shock. Another important field of application is in the construction of towers used in absorption, condensation, distillation, evaporation, extraction, filtration, scrubbing and other processes. Carbon Raschig rings are particularly applicable for towers which handle caustic solutions for absorbing acid gases. Other components in tower work would be bubble caps, distributor tubes, plates, gratings and trays.

In the field of metallurgy, carbon and graphite are being used for such parts as molds for static and centrifugal castings, parts for powder-metallurgy pressure molds, pickling tanks and tank linings, core rods, dies, gassifying tubes, heat treating boxes, furnaces and furnace linings, brazing trays, ladle and trough linings, etc.

In the electrical field there are carbon, graphite and metal-graphite brushes for motors, generators and converters; contacts for circuit breakers, controllers, signal relays, etc.; carbon rheostat disks and plates; graphite anodes, grids, etc., for electronic tubes; carbon diaphragms, transmitter disks, back plates, and granular carbon for telephones and microphones; carbon electrodes for lightning arresters; carbon arc-welding electrodes; carbon electrodes for soldering and brazing; ground anodes for cathodic protection of pipe lines, tanks and other metallic structures; lighting carbons for all types of arc lamps such as those used in motion picture projectors, etc.

Many forms and types of filters are made of porous carbon and graphite. These filters are particularly useful for filtration of highly corrosive liquids and gases and where thermal shock may be expected. Porous carbon is also ideal for units used in the dispersion of gas into liquid. The capillary, or wicking action, of porous carbon makes it suitable for use in humidifying and evaporating devices.

FABRICATION

MACHINING AND GRINDING:

Since carbon is hard and abrasive it is more difficult to machine than the other forms. However, with proper tool materials and techniques it can be turned, drilled, milled, sawed, ground and lapped. Only the high-carbon steels or cemented carbides are recommended for machining carbon, the tool steel being used as-quenched, without tempering, for maximum abrasion resistance. Carbon is always diamond sawed. Grinding is best accomplished with open-bond, coarse-grained vitreous wheels to insure against loading of the wheel, and of course grinding followed by lapping results in the smoothest surface finish.

Graphite can be machined with standard tools and with the same facility as wood. Not uncommon are finish tolerances on ground surfaces of plus or minus 0.00025-inch, while with lapping, a total tolerance of 35 millionths of an inch on some flat surfaces is being maintained in standard production. Grinding wheels used are the same as for carbon. With proper tooling, tolerances of machined surfaces on a production basis can be held within extremely close limits, in many cases as close as plus or minus 0.001-inch.

CHEMICAL RESISTANCE OF IMPERVIOUS CARBON AND IMPERVIOUS GRAPHITE

(inert to all but highly oxidizing conditions)

Resistant to These Reagents	Concentration (per cent)	Temp. (deg C)
Acetic acid	Glacial	B. Pt.
Acetic anhydride	100	B. Pt.
Acetone	100	B. Pt.
Air	...	170
Air (S)	...	200
Ammonia	20	R.T.
Ammonium thiocyanate	25	95
Amyl alcohol	100	B. Pt.
Aniline	100	110
Arsenic acid	75	125
Benzene	100	B. Pt.
Boric acid	25	B. Pt.
Bromine water (S)	Sat'd.	65
Butyl alcohol	100	B. Pt.
Butyl cellosolve	100	110
Camphor	.08	50
Camphor and	.08)	
Sodium hydroxide	3)	50
Carbon dioxide—water	Sat'd.	to 100
Carbon monoxide—water	Sat'd.	to 100
Carbon tetrachloride	100	B. Pt.
Cellosolve	100	110
Cellosolve	25	110
Chlorethylbenzene (S)	Tech.	125
Chlorine, dry	Gas	R.T.
Chlorine water (S)	Sat'd.	R.T.
Chloroform	100	B. Pt.
Citric acid	25	B. Pt.
Cupric chloride	10	95
Dioxan	100	B. Pt.
Ethyl alcohol	95	B. Pt.
Ethyl mercaptan—water	Sat'd.	to 100
Ethylene dichloride	100	B. Pt.
Ferric chloride	15	to 60
Ferric chloride (S)	25	B. Pt.
Ferrous chloride	40	B. Pt.
Ferrous sulphate	25	B. Pt.
Formic acid	90	B. Pt.
Formic acid and	3)	
Potassium dichromate	1)	70
Freon—11 ($CFCl_3$)	100	R.T.
Freon—12 (CF_2Cl_2)	100	R.T.
Gasoline	100	B. Pt.
Glycerine	100	135
Hydrobromic acid	40	B. Pt.
Hydrochloric acid		B. Pt.
Hydrofluoric acid	15	B. Pt.
Hydrogen peroxide and	8)	...
Mercuric nitrate and	10)	R.T.
Nitric acid	5)	...
Hydrogen sulphide—water	Sat'd.	to 100
Isopropyl acetate	100	B. Pt.
Isopropyl alcohol	100	B. Pt.
Isopropyl ether	100	B. Pt.
Kerosene	100	to 160
Lactic acid	25	B. Pt.
Manganous sulphate	15	95
Mannitol	25	B. Pt.
Methyl alcohol	100	B. Pt.
Methyl isobutyl ketone	100	B. Pt.
Monochlorbenzene	100	B. Pt.
Monoethanolamine	10	96

Resistant to These Reagents	Concentration (per cent)	Temp. (deg C)
Nickel chloride $6H_2O$ and	300 g/l)	
Boric acid	30 g/l)	75
Nickel sulphate $6H_2O$ and	318 g/l)	....
Nickel chloride $6H_2O$ and	16.5 g/l)	75
Boric acid	30 g/l)	...
Nitric acid (S)	2	R.T.
Nitric acid (S)	10	to 85
Nitrobenzene	100	135
Octyl alcohol	Tech.	B. Pt.
Oleic acid	100	135
Oxalic acid	25	135
Oxalic acid and	Sat'd.)	
Nitric acid	0.3)	R.T.
Paraldehyde	100	110
Paraldehyde—water	Sat'd.	110
Paradichlorbenzene	100	125
Petroleum oil	100	160
Phenol	100	110
Phenol	25	110
Phosphoric acid	25	B. Pt.
Phosphoric acid	50	135
Phosphoric acid	85	to 185
Potassium permanganate and	3)	
Sulphuric acid	10)	R.T.
Rayon Solutions		
Na_2SO_4	12–20	60
H_2SO_4	8–12	...
$Mg\ SO_4$	4–6	...
$Zn\ SO_4$	1	...
Sodium chloride	25	B. Pt.
Sodium dichromate and (S)	5)	
Sulphuric acid	10)	R.T.
Sodium hydroxide (S)	to 80	to 135
Sodium hydroxide and	3)	
Camphor	.08)	50
Sodium hydrosulphite	3	R.T.
Sodium hydrosulphite and	3)	
Hydrochloric acid	0.1)	R.T.
Sodium hydrosulphite and	3)	
Sodium hydroxide	0.1)	R.T.
Sodium hypochlorite (S)	5	R.T.
Sodium nitrate and	25)	
Sodium carbonate	5)	110
Sodium nitrate and	Sat'd.)	
Sodium carbonate	5)	110
Sodium sulphate and	30)	
Sulphuric acid	15)	121
Stannic chloride	15	B. Pt.
Stearic acid	100	135
Sulphuric acid	to 75	to 135
Sulphuric acid	96	to 80
Sulphuric acid (S)	96	to 150
Sulphuric acid and	96)	...
Chlorine and	Sat'd.)	45
Hydrogen chloride	Sat'd.)	...
Sulphurous acid	7	R.T.
Tartaric acid	25	B. Pt.
Tetramine C	10	96
Water	100	to 100
Zinc chloride	53	120

Note: (S) indicates that material with special impregnants is required.

MOLDING:

Molding of graphite and carbon-graphite parts may be likened to the molding of powder-metals. The powdered materials are pressed to shape in dies and the resulting parts are baked in a controlled-atmosphere furnace at up to 3000 F. Shapes of parts should be as simple and symmetrical as possible and free of undercuts occurring perpendicular to the direction of molding-die movement. In general, tolerance on molded parts is about 1 per cent of the dimension on inside and outside diameters with a minimum of 0.010-inch and 10 per cent on length or thickness. Where closer tolerances are necessary, the molded part must be machined, ground or lapped, depending on size-accuracy requirements or smoothness of surface demanded by the application.

(*Concluded on next page*)

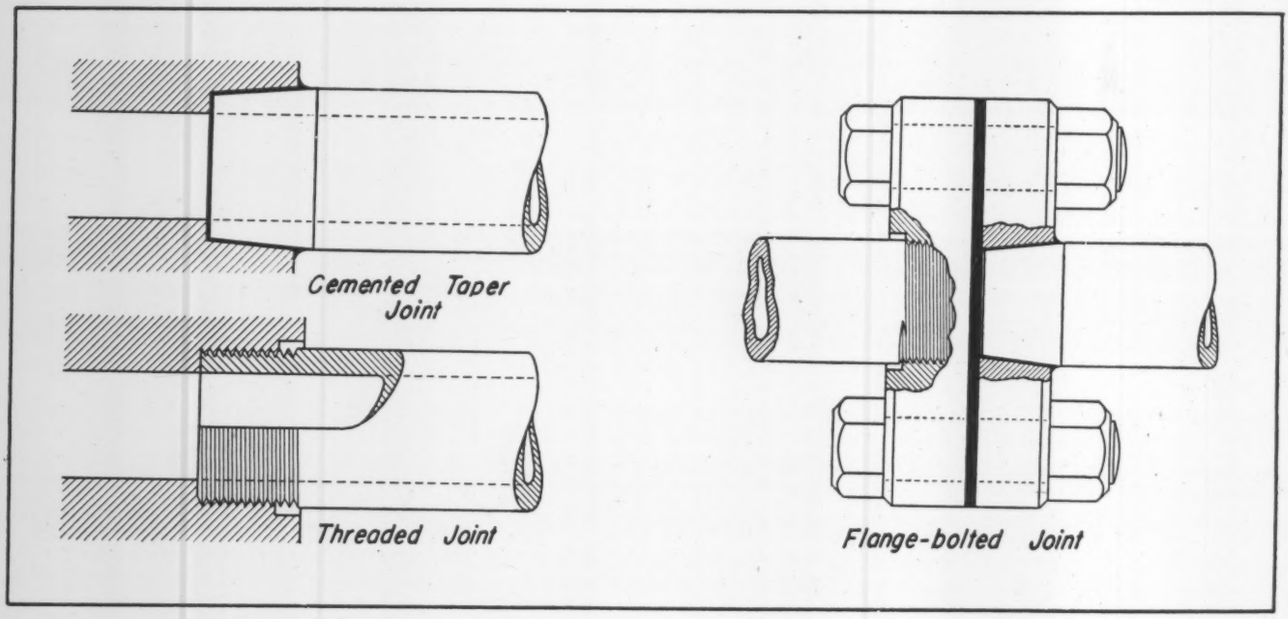
METHODS OF FASTENING

Carbon or Graphite to Rubber: Two general methods are employed; attachment by cold-setting or heat-and-pressure setting cement, and attachment by vulcanization. With both the carbon must be absolutely clean if a reliable bond is to be effected.

Carbon or Graphite to Metal: Methods in general use are: Soldering, shrink and press fitting, cementing and bolting. Soldering obviously is limited to low-temperature applications because of the low melting point of the solder. Before soldering, the carbon is coated with copper. High-melting-point silver solders usually are not successful because most metals have coefficients of thermal expansion two to three times that of carbon. Consequently, as the soldered unit cools it either warps or breaks, or the metal pulls away from the carbon. When press fitting is used, a good deal of caution must be exercised. The carbon member should be of substantial section or solid and pressed into a hole in the metal, rather than the metal pressed into a hole in the carbon. This is because carbon is considerably stronger in compression than it is in tension. However, even in compression it is not as strong as most metals. Cementing of parts may be done with either cold-setting or heat-and-pressure setting cements. Where parts are joined by bolting, through-bolts should be used or the threads receiving the bolt should be cut in the metal member. In addition, the joint should be of such design and the bolt holes of sufficient clearance to permit relative expansion of the carbon and metal members throughout the operating temperature range.

Carbon to Carbon or Graphite to Graphite: Methods generally employed are: Through-bolting, cementing and threading. Ordinarily threading of carbon parts should be avoided. Only comparatively large parts of carbon should be threaded because the material will not hold a fine thread. Graphite and impervious carbon and graphite parts on the other hand, will hold finer threads (down to about 16 pitch). Nevertheless, threads cut on either carbon or graphite parts should be as coarse as is practicable.

Cemented, threaded and flange-bolted joints are illustrated in the accompanying drawings. The cemented taper joint is the simplest type of connection, is low in cost, yet strong, leakproof and durable when properly assembled. Threaded pipe joints are not tapered, as is customary with metal pipe, and should be cemented to insure freedom from leakage. It is recommended that flange couplings used on carbon and graphite pipe and similar assemblies conform in diameter, bolt circle, and size and number of bolts to 250-lb iron flange standards. A gasket of rubber, or other material resistant to reaction with the product handled, is used between the flanges. The flanges are flat faced and should be used only against flat-faced companion flanges.



DESIGN TIPS

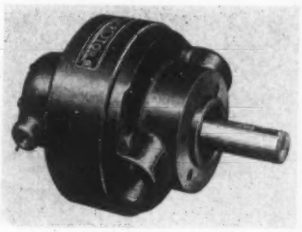
When designing machine parts to be made of carbon, graphite or one of the combinations thereof, it is well to bear in mind the inherent brittleness of these materials and the fact that they do not have the strength of most metals. For example, when supplanting a metal bearing with a carbon-graphite bearing, the same bore size may be retained but the bearing's cross-sectional area should be increased. An excellent method of anchoring such bearings in place is, where practicable, by shrink fitting, and for nominal-size bearing outside diameters the interference fit (on diameter) may range from 0.0005 to 0.0025-inch. In such cases, of course, the housing is heated to expand its bore and the bearing is merely dropped into place. Where it is feasible, shrink-fitting is more effective than press fitting and results in more accurate, reliable control of inside-diameter close-in.

In general, it is wise, where function permits, to chamfer or radius all edges and corners of carbon and graphite parts as this will minimize chipping. Pressures on rotating seals should only be sufficient to overcome and provide a factor of safety against the pressure of the liquid or gas to be sealed. Excessive pressure results in unnecessary heating and wearing of the seal parts. For maximum service life, metal nose pieces used with carbon-graphite seal rings should be extremely hard and honed to a mirror-like finish.

new parts and materials

To obtain additional information on these new developments see Page 239

Hydraulic Motor



SIZES UP to 8.7-horsepower hydraulic motors have been added to the Gerotor May line of hydraulic units. Operating on the "planetary gear" principle the motors provide flat characteristics along wide shaft speed ranges. Because of low rotational inertia, motors are capable of infinite and rapid variation in shaft speed rotation and can be stalled under load without damage. Units are available in plain, base or flange mounting. Direct coupling, belt, chain, or gear drives are available. Three basic types of the unit are the clockwise, counter-clockwise, or reversible. Manufacturer: Gerotor May Corp., P. O. Box 86, Baltimore 3.

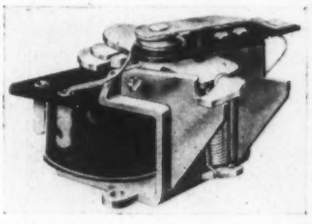
For further information circle MD 1 on card Page 239

Aluminum Gas-Line Tubing

FLEXIBLE ALUMINUM TUBING in 2S-O and 2S-1/2H aluminum, discontinued by Reynolds during the war, is now available in outside diameters ranging from ¼ to 1⅛-in. Standard wall thicknesses range from 0.049-inch for the ¼ to ⅝-inch OD tubing, 0.058-inch for ¾-inch tubing, and 0.065-inch for the ⅞ to 1⅛-inch sizes. Smaller wall thicknesses of 0.032-inch for ¼ and 5/16-inch OD, 0.035-inch for ⅜ and 7/16-inch OD, 0.042-inch for ½, 9/16 and ⅝-inch OD, and 0.049-inch for ¾ and ⅞-inch OD tubing are also available. Manufacturer: Reynolds Metals Co., 2500 So. Third St., Louisville 1.

For further information circle MD 2 on card Page 239

Motor-Starting Relay



DESIGNED SPECIFICALLY for use with single-phase ac capacitor motors, new relay is said to assure positive and more reliable motor performance. Essentially, this capacitor-motor starting relay is a potential-sensitive device operating over a wide range of voltages, as distinguished from the close-differential current-type relay. Chatterless operation is obtained through its unique magnetic circuit design. Contacts are single-pole, normally-closed type suitable for operation of a load as large as 1 hp, 115 volt, 60-cycle capacitor motor. Relays measure 1½ inches high, 1¾ inches wide and 1 15/16 inches long and are sturdily built. Manufacturer is the Ward Leonard Electric Co., Mount Vernon, N. Y.

For further information circle MD 3 on card Page 239

Axial Air-Gap Motors

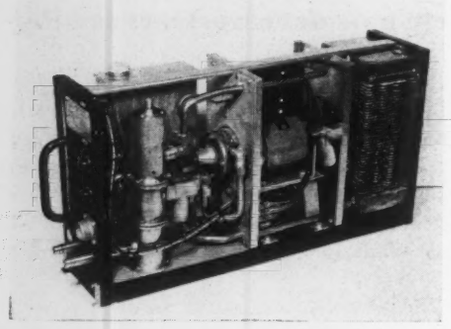
APPRECIABLE REDUCTION in axial length and in weight of electric motors is achieved by the new Axial Air-Gap design. Line of motors ranging in size from 1/3 to 10 horsepower has approximately 70 per cent of the weight of conventional types, yet retains all the necessary characteristics of sturdiness and power requirements. The motors are distinguished by the fact that the magnetic lines of force follow a path parallel to the motor shaft as compared to a radial path taken by magnetic flux in conventional motors. Rotor and stator laminations are welded to cast-in steel inserts in their respective spiders, the stator spider being the flange mount and carrying an integral quill to support the outboard bearing. In this manner the motor frame is within the stator and rotor assemblies, making the motor in effect "inside out". The outboard bearing is a floating single-row ball bearing while the main bearing is a double-row thrust ball bearing. Cover is stamped and may be removed readily for inspection without disturbing the bearings or other parts. Because of their short length, units are specially recommended for applications where axial space is limited. Styles are available for horizontal, vertical or angle-base mounting. Design is not, however, intended for belt or chain drive. Manufacturer: Fairbanks, Morse and Co., 600 S. Michigan Ave., Chicago 5.

For further information circle MD 4 on card Page 239

Heat Exchanger

EQUIPPED with four-bank radiator, cooling fan, circulating pump, reservoir, etc., the Eastern Model No. 1 heat-transfer unit will dissipate up to 1000 watts depending upon operating-temperature range. Unit utilizes

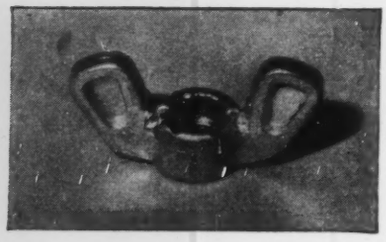
through-shaft motor with pump and fan mounted on opposite ends. Motor is 1/40-hp operating at 3450 rpm on 110 volts ac. Overall size is 19⅝ inches by 5¼ inches by 10½ inches, and approximate weight is 40 lb. Exchanger



is recommended for use in connection with television, high-pressure mercury lamps, high-frequency power tubes, motion-picture projectors, induction-heating units, etc. Manufacturer: Eastern Industries, Inc., New Haven 6, Conn.

For further information circle MD 5 on card Page 239

Self-Locking Nut

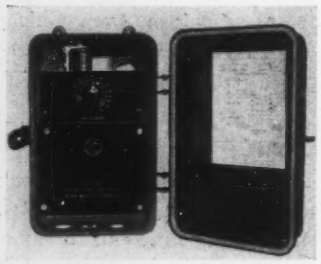


LOCKING WING NUT has an elastic nylon locking collar with the ability to lock in position anywhere on a stud or bolt. The new fasteners are available in four diameters with both fine and coarse threads. Machine screw sizes in fine threads are: 8-36, 10-32 and 12-28 with a fractional size of ¼-28. Coarse thread sizes are 8-32, 10-24 and 12-24 in addition to ¼-20. Tests show retention of locking effectiveness through 200 applications and removals. Manufacturer: Elastic Stop Nut Corporation of America, 115 Broadway, New York.

For further information circle MD 6 on card Page 239

Timer Controller

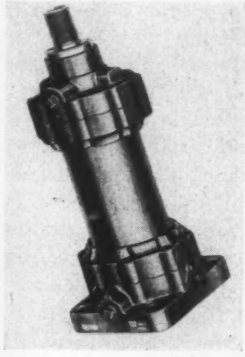
TYPE 30CR3 Photoswitch electronic welding timer is designed for interval timing of welding operations over a range of 3 to 120 cycles. It is recommended for general - purpose spot welding use. Timer incorporates many features of particular importance



to the welding field. For example, the timing adjustment can be set for any interval from 3 to 120 cycles with accuracy throughout range within 2 per cent. Timer may be used with either 115 or 230 volts ac supply, providing heat or nonheat timing. Operating on 60 cycle 25 watt power, the unit has a relay contact rating of 10 amperes 115 volts ac noninductive, or 5 amperes, 230 volts ac noninductive. Manufacturer: Photoswitch Inc., 77 Broadway, Cambridge 42, Mass.

For further information circle MD 7 on card Page 239

Hydraulic Cylinders

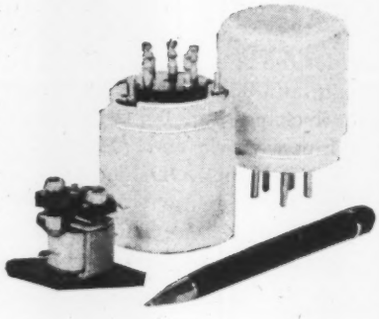


LINE OF hydraulic cylinders for service up to 1500 psi now includes two larger sizes, 7 and 8 inch bores. Cylinders have bored and honed bodies, automotive type piston rings and interchangeable end caps. With this addition the series has nine standard mounting styles with a standard rod, large rod or double-end rod. Manufacturer is the Hannifin Corp., 1101 South Kilbourne Ave., Chicago 24.

For further information circle MD 8 on card Page 239

Current-Sensitive DC Relays

RELAYS ranging in capacity from 10 to 180 milliwatts are designed for electronic applications where switching must be performed by small amounts of power. The relays, ranging from 0.07 to 67,000 ohms, have current ratings from 0.47 to 1470 milliamps. Contact-voltage ratings are from 12 to 110 volts, ac or dc. At 24 volts dc the contacts will handle 2 amperes noninductive or 0.5 amperes inductive. The relays are built to withstand shock and vibration and can be provided with solder-lug or plug-in terminals. All forms excepting the 150 milliwatt size have metal covers. Manufacturer: General Electric Co., Apparatus Dept., Schenectady, N. Y.



For further information circle MD 9 on card Page 239

Dielectric Heating Generator

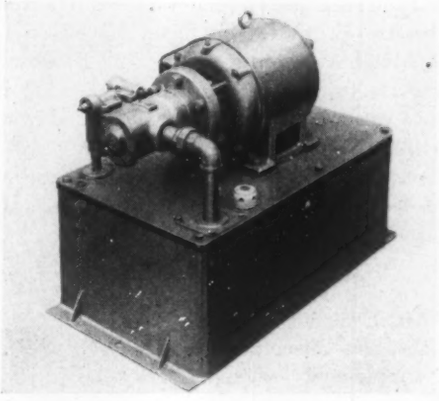
RADIO-FREQUENCY GENERATOR rated at 2 kilowatts features a dual set of operating controls permitting alternate operation of generator on two different time cycles. It is thus possible with the single generator to supply two demands operating on different loads. The

40.9 mc set has two adjustable automatic timing relays built into control panel, providing alternate power-on period of from 0 to 165 seconds. Separate start and stop pushbuttons and load indicator lights are provided. Input current meter and filament indicator are in the center of the control panel. Employing two type WL-872-A rectifier tubes and an industrial type aircooled WL-473 oscillator tube, the new generator is equipped with an airmaze cleanable filter for dust-free cooling air. Cubicle is of medium-gage steel with aluminum for radio-frequency shielding. Manufacturer: Westinghouse Electric Corp., P. O. Box 1017, Pittsburgh 30.

For further information circle MD 10 on card Page 239

Hydraulic Power Units

LINE of hydraulic power units is available in standard sizes and types of 20, 30 and 60-gallon tank capacities. All units are equipped with Vickers constant-delivery vane-type pump available in three types in a wide range of capacities. These include single and two pressures for

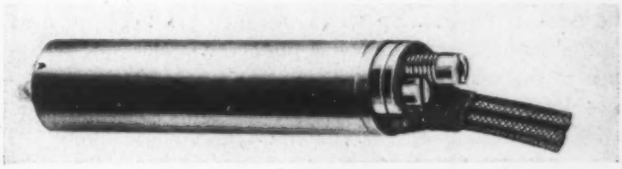


1000 psi, and two stage for 2000 psi continuous duty. An integral unit, all intermediary piping between pump and oil reservoir is provided. Pumps are arranged to accommodate electric motors of user's selection and combine oil reservoir, pump, suction filter, combination filler cap and air cleaner, oil-level gage and other accessories for a complete power source for hydraulic systems. Manufacturer: Vickers Inc., 1430 Oakman Blvd., Detroit 32.

For further information circle MD 11 on card Page 239

Miniature Thermostat

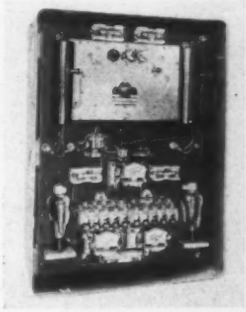
THERMOSTAT of small size and weight is said to be resistant to vibration effects. Unit, which operates on an expanding-tube principle is known as the Scaico. It consists of ½-inch diameter brass or stainless steel tube 2 inches long, in which heavy-duty contacts are carried on low-expansion nickel-iron struts. The outer case acts as the temperature-sensitive element and the contact action is caused by the difference in expansion rate of the outer shell and the inner struts. The whole assembly is completely soldered, welded or riveted and no linkage or pins



are used. Result is an extremely compact and sturdy mechanism responsive to a fraction of a degree change in temperature. Control ranges are from −100 to +600 F and adjustment is easily made by simply turning an adjusting screw. Maximum capacity is 600 watts. Larger units ⅝-inch in diameter and 3 inches long are available with same sensitivity and temperature range but have load capacity up to 2500 watts. Manufacturer: Smith Control & Instrument Corp., Needham, Mass.

For further information circle MD 12 on card Page 239

Electronic Motor Control



CONTROLLER designed to operate dc motors in sizes up to 2 hp from ac power has recently been announced. Unit has a closely regulated characteristic providing an almost flat speed-torque curve with changes in load having little effect on speed. For any speed setting performance is practically equal to that of a synchronous motor even with a suddenly applied load. Manufacturer is the Federal Electric Products Co., 50 Paris St., Newark 5, N. J.

For further information circle MD 13 on card Page 239

Mild-Steel Electrodes

TYPE SW-2 ELECTRODE for rapid and economic welding of mild steel with either ac or dc current is now being offered in four diameters from 3/16 to 5/16-inch. Welds made with the new type electrode meet the requirements of AWS-ASTM specifications for classifications E-6012 and E-6013. It provides freedom from undercutting and extreme ease of slag removal. Manufacturer is the Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30.

For further information circle MD 14 on card Page 239

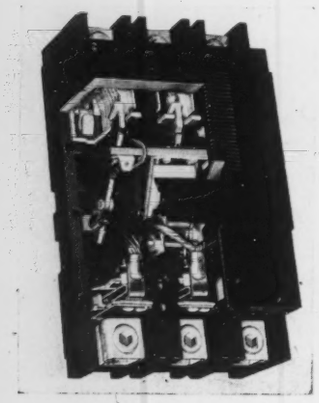
Unloading Pump

COMPACT HYDRAULIC PUMP obviates check valve, relief valve, unloading valve and pressure accumulator. Unloading pump is of the gear type and actually consists of two pumps within a single housing. Pilot valve, which is an integral part of the pump assembly, controls an opening in the passage communicating from the outlet

port to the rear of the movable bearings in the cover of the pump. When a specified pressure has been reached in the hydraulic system, the pilot valve closes the passage to the rear of the bearings thus eliminating the pressure loading. Pressure in the gear-teeth area forces the cover bearings away from the gear and immediately the large section of the pump ceases to deliver fluid with a consequent decrease in horsepower input requirement. Small section of pump continues to deliver fluid under pressure keeping the hydraulic alive during period of small demand. Manufacturer: Pesco Products Division of Borg-Warner Corp., 11610 Euclid Ave., Cleveland 6.

For further information circle MD 15 on card Page 239

Circuit Breaker



COMPACT 225-ampere frame industrial circuit breaker measures 10⅜ inches high by 6 inches wide and is approximately one-half the size of the device formerly made by this manufacturer. The new type ML-3 breaker is rated 125 to 225 amperes and will break comparable voltages up to 250 volts ac or dc and 600 volts ac or 250 volts dc, respectively. Unit is sheet steel, having dust resisting enclosures with side-operated handle for 3 and 4-wire solid-neutral applications. It is furnished in panelboards and switchboards, front or back connected, as well as the standard cabinet model. Manufacturer: Square D Co., 6060 Rivard St., Detroit 11.

For further information circle MD 16 on card Page 239

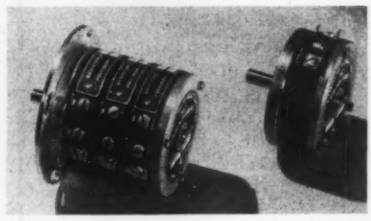
Hydro Pneumatic Power Unit

DOUBLE-ACTING hydro-pneumatic power unit is now available from the Aldrich Pump Co., 2 Gordon St., Allentown, Pa. The unit is operated by a vertical double-acting air piston direct-connected to the pump plunger, and yoke connected to the downward-acting plunger. Pump cylinders are opposed and of integral construction. Hydraulic pressures up to 20,000 psi can be obtained with a maximum air pressure of only 100 psi.

For further information circle MD 17 on card Page 239

Ganged Potentiometer

LINEAR, wire-wound potentiometers are now available in single units or ganged in multiple on one shaft to provide independent voltage outputs for several related variables. Potentiometer is a custom-built type with critical parts fabricated from precious-metal alloys. Instrument obtains the accuracy of 0.1 per cent in the larger size and 0.15-per cent in the two-inch smaller size. Service life is guaranteed to exceed one million cycles and life tests indicate that four to five times this figure can be expected when rotational speeds are not excessive. Features of the unit include very-wide angle of electrical rotation (351 degrees and 355 degrees for the two-inch and three-inch sizes, respectively) torque requirements less than one



ounce-inch, power dissipation four and five watts respectively and wide overall resistance range from 100 to 100,000 ohms. Manufacturer: Fairchild Camera & Instrument Corp., Jamaica, N. Y.

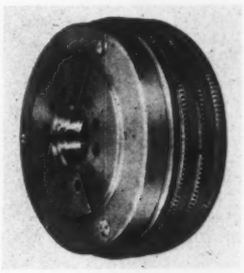
For further information circle MD 18 on card Page 239

Electrodes

LINE OF Murex heavy-coated aluminum-bronze and phosphor-bronze electrodes has been placed on the market by the Metal & Thermit Corp., 120 Broadway, New York. New electrodes are available in a wide range of bronze alloys varying in chemical analyses and in mechanical properties. Deposits have good wearing and bearing characteristics and excellent corrosion resistance.

For further information circle MD 19 on card Page 239

Air-Actuated Clutch



AVAILABLE in 30, 36 and 42-inch sizes, new air-actuated clutches supplement regular line of Twin Disc models. Clutches range in capacities from 75 hp to 1325 hp with torque ratings from 900 to 89,550 pound-feet. The air-actuated model PH series operate by remote control without a complicated linkage system, thus greatly reducing shaft space. They offer ideal operating characteristics because any desired amount of air pressure, within practical limits, can be applied to friction plates to provide either slow or fast engagement. The newly designed clutches, of heavy, new-type spline tooth construction, are equipped with clutch hub, center plates, and floating plates. Manufacturer: Twin Disc Clutch Co., Racine, Wisc.

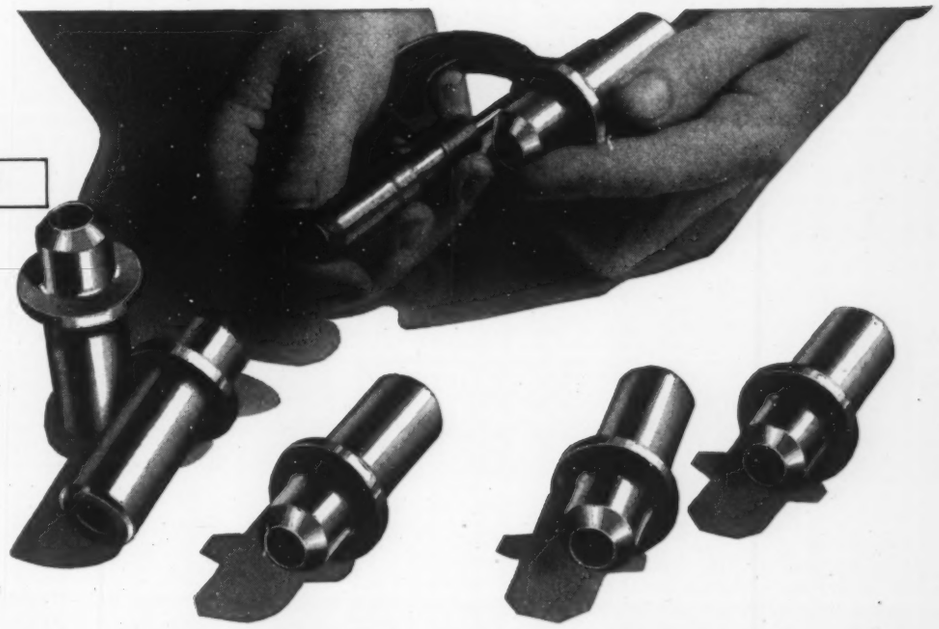
For further information circle MD 20 on card Page 239

Screen Trap for Pipes

MAGNETIC SCREEN trap for incorporation in lines carrying oil, gasoline, air, gas, etc., has a special mesh screen and a powerful Eriez alnico permanent magnet built into a single, compact unit. Body of trap is brass,

Johnson Bronze Sleeve Bearings Give You Every Worthwhile Advantage

- LOW COST
- PRECISION
- QUIET
- LONG LIFE
- CORROSION RESISTANT
- UNIT CONSTRUCTION
- LOAD CARRYING CAPACITY
- HIGH RESISTANCE TO SHOCK
- LOW COEFFICIENT OF FRICTION
- EASY TO INSTALL
- CONFORMABILITY
- NATION WIDE SERVICE

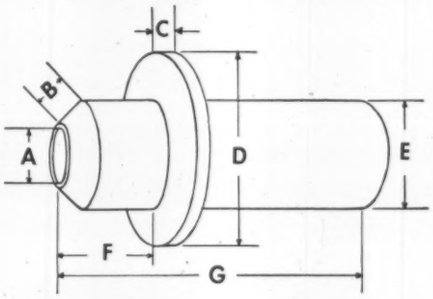


The MODERN ASSEMBLY LINE *depends on* PRECISION

Ever watch the assembly line in a modern industry? They take gears produced in New England . . . shafts turned in Ohio . . . housings cast in Indiana . . . and Sleeve Bearings made in New Castle. With a few facile movements by the operator a motive unit is produced . . . ready to run. This simplified assembly is possible *only* when each manufacturer works to a precise set of measurements . . . clearly defined tolerances.

Producing Sleeve Bearings *exactly* according to specifications is an easy assignment for Johnson Bronze. We have the men . . . the machines . . . and over forty years' exclusive bearing experience. We can help you select the correct *type* of bearing . . . help you decide on the proper dimensions . . . and then produce your requirements right in every detail . . . *and on time*. Why not call us in TODAY?

Precise AT EVERY POINT



A—*Inside Diameter* . . . concentric with outside diameter.

B—*Chamfer* . . . right length . . . correct angle.

C—*Flange Thickness* . . . stout enough to take the thrust.

D—*Flange Diameter* . . . ample enough to distribute the load.

E—*Outside Diameter* . . . correct dimension for easy assembly.

F—*Flange Position* . . . to "locate" the bearing.

G—*Length* . . . held to right limits . . . sufficient to carry the load.

X—*Alloy*—Selected to suit operating conditions.

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JOHNSON BRONZE
SLEEVE BEARING HEADQUARTERS
BRANCHES IN 18 INDUSTRIAL CENTERS

bronze or aluminum, and screen is inserted without use of braces, stanchions or supports, thus offering a clear and unobstructed filtering area. Combination of screen trap and magnet, when placed in line, stops all abrasive material both magnetic and nonmagnetic. Filtering unit is separable from trap body, facilitating cleaning, renewal or change of wire mesh. Manufacturer: Cooney Valve & Screen Co., 1-M P. O. Box No. 1358, Erie, Pa.

For further information circle MD 21 on card Page 239

Thermostat

SMALL PRESET TYPE of thermostat, available for use at temperatures up to 550 F, is rated up to 1500 watts, either 110 or 220 volts ac. Chief among advantages of the unit is a substantially improved accuracy of operation over its prior model and longer life. Point life has been obtained by a slight wiping action of ¼-inch silver points minimizing pitting or sticking of contacts. The Master Mite thermostat is completely jacketed in aluminum, copper or nickel and insulated with silicon-impregnated fiber glass. It is moistureproof, dustproof, tamperproof, and adaptable to immersion in liquids. Classified as a heavy-duty, miniature thermostat the Master Mite measures ¼-inch thick, ½-inch wide and 2½ inches long. Manufacturer: Mechanical Industries Production Co., 203 Ash St., Akron 3.

For further information circle MD 22 on card Page 239

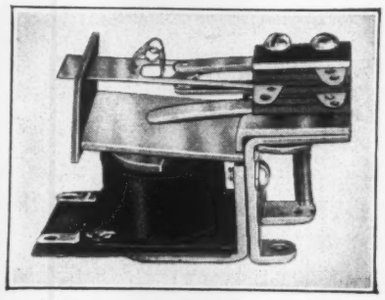
Miniature Phototube

CAPSULE-SIZE PHOTOTUBE about the size of a .22 caliber rifle cartridge is said to be the smallest phototube ever offered commercially. The tube, designated as the RCA-1P42, has a maximum diameter of only ¼-inch and an overall length just under 1 13/32 inches and is activated by light entering a tiny window at its larger end. Tube compares favorably with larger phototubes in sensitivity and makes possible sharper and clearer features in applications. Manufacturer is the Radio Corp. of America, RCA Victor Division, Camden, N. J.

For further information circle MD 23 on card Page 239

Snap-Action Switch

SNAP ACTION switch, designed for control applications involving slow-moving mechanical devices, utilizes the action of a hair spring which holds contact assembly at either open or closed position until the armature has completed its travel. The switch is free of chattering, arcing and intermittent contact pressures. Unit, which is available in conjunction with standard Guardian relays, will serve to disconnect starting winding when motor reaches running speed and to apply additional torque when motor is overloaded by closing the condenser circuit. Switch relay can also be used in place of a centrifugal



switch normally installed in motor housing. When motor is of the hermetically-sealed type, relay may be incorporated into the circuit outside the unit. Manufacturer: Guardian Electric Manufacturing Co., 1601 West Walnut St., Chicago 12.

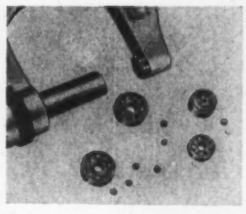
For further information circle MD 24 on card Page 239

Electronic Welding Timer

COMPLETE LINE of nonsynchronous packaged ac resistance welding controls known as Weld-O-Timers has recently been placed on the market. Made in two frame sizes, 1200 and the 600, the timers are provided with a convenient access door, metal in the case of the 600 frame size and transparent material in the case of 1200 frame size. Manufacturer is the Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30.

For further information circle MD 25 on card Page 239

Miniature Ball Bearings



NEW LINE of precision solid-race ball bearings in radial and pivot designs is now being produced in both English and metric dimensions from 5/32 to 3/8-inch outside diameter. Bearing rings and cups are machined from solid bar alloy steel heat-treated to optimum properties and microfinished on running surfaces. Full race radial bearings of 1/4 to 3/8-inch outside diameter in inch sizes, and pivot type bearings from 5/32-inch to 3/8-inch outside diameter are offered. Manufacturer is New Hampshire Ball Bearings, Inc., Peterborough, N. H.

For further information circle MD 26 on card Page 239

Stainless Welding Electrodes

STAINLESS STEEL electrodes in a full range of grades and diameters have been announced by the Electric Welding Division of the General Electric Co., Schenectady.

LEATHER

FABRICATED

NOT JUST ONE TYPE OF PACKING

-BUT 4

. . . PLUS A DESIGN SERVICE ONLY HOUGHTON CAN RENDER

Being "neutral," in that we supply both leather and synthetic rubber packings for all hydraulic and pneumatic applications, we can recommend the best type for each individual need. Our engineering service, already familiar and helpful to design and maintenance men the country over, is yours to command. E. F. Houghton & Co., 303 W. Lehigh Ave., Philadelphia 33, Pa.

"O" RINGS

HOMOGENEOUS

HOUGHTON'S

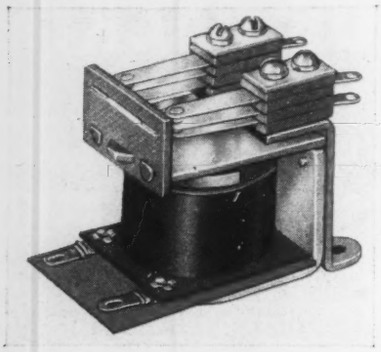
VIM LEATHER AND VIX-SYN PACKINGS

The electrodes are available in two types of coatings, one designed for ac or dc use and the other for reverse polarity dc operation. They can be used in all welding positions. Stability of the arc and deposition characteristics assure flat fillet welds, reducing grinding. Stable arc characteristics also permit good directional control. Electrodes are wrapped in five-pound rolls and furnished in twenty-five and fifty-pound packages.

For further information circle MD 27 on card Page 239

Interchangeable-Part Relays

SERIES 600 Guardian relay, which is now available, is capable of performance equal to many larger and more expensive relays while priced to meet needs for small, compact, low-cost relays. The unit is comprised of two basic parts—a coil assembly and a contact assembly.



Each part is interchangeable. Thus the operating voltage may vary from 3 to 230 volts ac, or 3 to 110 dc with maximum contact current equal to 8 amperes and power consumption of 6 volt-amperes. Manufacturer is the Guardian Electric Mfg. Co., 1601 West Walnut St., Chicago 12.

For further information circle MD 28 on card Page 239

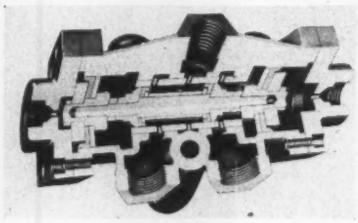
Welding Electrodes

FIVE KNURLED-TYPE wires, and five flux-impregnated welding tapes all recommended for low-cost, uniform automatic welding are now available. The electrodes are made in several diameters and alloy analyses and wires may be used separately or in conjunction with tapes. Manufacturer is the Wilson Welder & Metals Co., Inc., 60 East 42nd St., New York 17.

For further information circle MD 29 on card Page 239

Pneumatic Control Valve

AIR CONTROL valve with sliding-piston construction eliminates valve seats and rod packings and thus provides longer life. Seventy-five models in the new 150 psi line provide for line variations in pneumatic valve speeds. Manual, toggle, foot, cam, light duty, remote operated and other models are provided in numerous types and sizes. All valves use the Logan balanced-piston design which provides equal pressure on both sides of piston. Self-cleaning construction which wipes piston walls clean of abrasive particles with every piston movement provides



longer sealing life, while durable synthetic-rubber cup packings assure positive action without leakage. Manufacturer: Logansport Machine Co. Inc., 905 Center Ave., Logansport, Ind.

For further information circle MD 30 on card Page 239

Rhodium Plating

IMPROVED quality rhodium plating has been announced by P. R. Mallory & Co. Inc., Indianapolis 6. The improved Mallory process is said to assure freedom from shadows, pin holes and blisters said to normally accompany heavier coatings, and make possible unusually heavy deposits with a desirable hardness, brilliance and corrosion resistance inherent in metallic rhodium.

For further information circle MD 31 on card Page 239

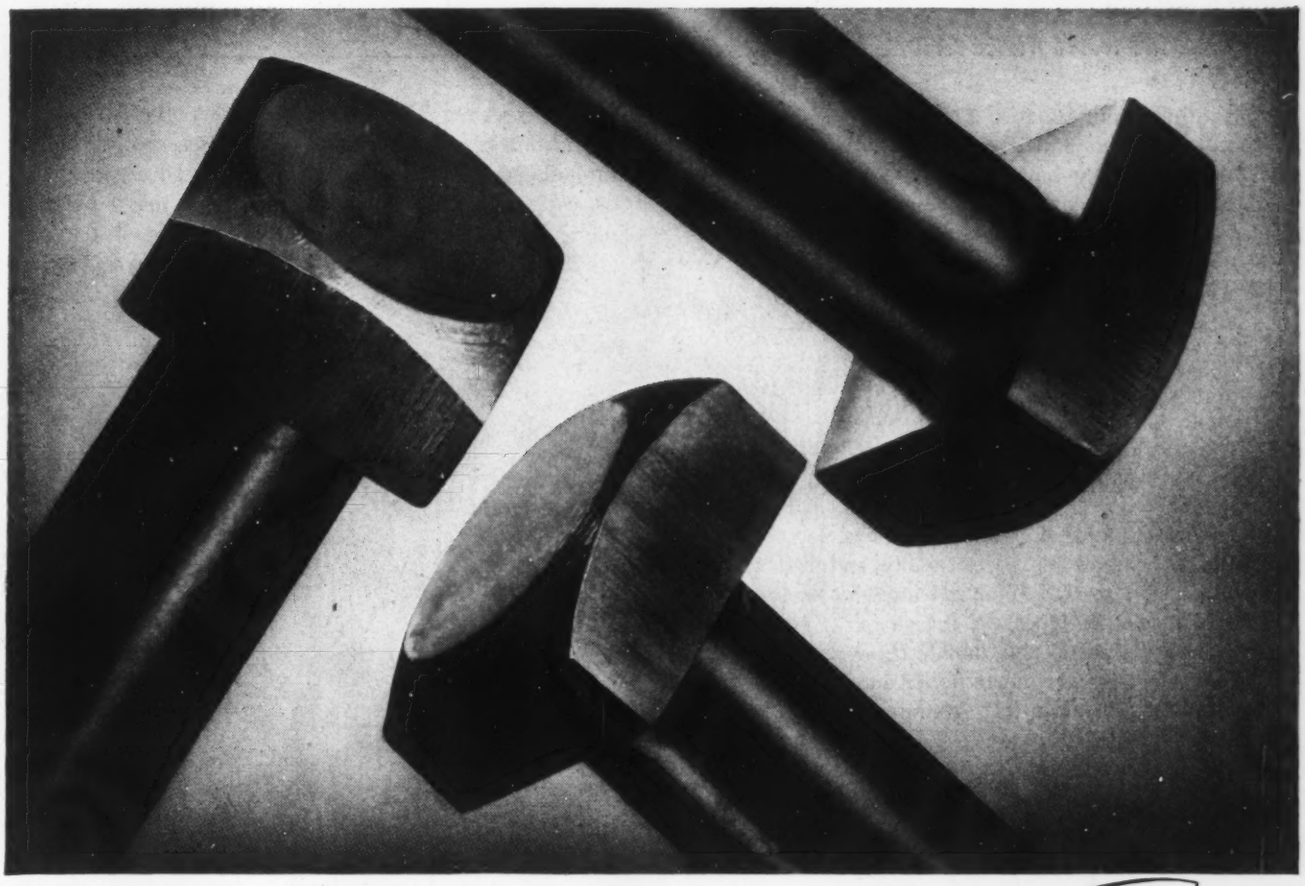
Air Filter

DESIGNED TO remove oil fog from the supply air used by gages and other pneumatic instruments, a new air filter will trap 92 per cent of the entrained oil from the pneumatic system. Pressure drop through the Moore air filter with a supply pressure of 75 psi and a flow of 0.5 cfm is approximately ⅛ psi. Filtering material is contained in an open-end brass cylinder mounted on a brass housing. Air enters the top of the inner cylinder, passes down through the filtering material and up between cylinder and housing. Trapped oil and moisture are retained in bottom chamber till blown off. Unit is of brass and bronze construction, 2⅛ inches in diameter by 9 inches long and has ¼-inch pipe connections. Manufacturer: Moore Products Co., H & Lycoming Sts., Philadelphia 24.

For further information circle MD 32 on card Page 239

Discharge Capacitors

ENERGY-STORAGE capacitors known as the Solar Type QLX series are recommended for such uses as capacitor-discharge welding, pulsed lighting applications, high-intensity flashing signs, beacons, etc. The condens-



WHEN YOU SAVE PRODUCTION TIME BY USING FEWER TYPES AND SIZES...THAT'S t.f.e. True Fastener Economy!

It's the cost of using a fastener that counts

And an important part of the cost of using a fastener is the cost of maintaining inventories, requisitioning from stock, handling many different styles and sizes. Careful analysis of fastening requirements and standardization on fewer types and sizes will help to speed up production and lower costs.

RB&W Machine and Carriage Bolts Offer You Unlimited Variety

RB&W engineers are available to help you determine the minimum variety of types and sizes of bolts and nuts which will meet your needs. And RB&W offers the maximum range of product, a choice of many special metals, and the facilities of a versatile finishing department—from a *single* source of supply.

You Get T. F. E. When You

1. Reduce assembly time to a minimum by savings through use of accurate and uniform fasteners
2. Make your men happier by giving them fasteners that make their work easier
3. Reduce need for thorough plant inspection, due to confidence in supplier's quality control
4. Reduce the number and size of fasteners by proper design
5. Purchase maximum holding power per dollar of initial cost, by specifying correct type and size of fasteners
6. Simplify inventories by standardizing on fewer types and sizes of fasteners
7. Save purchasing time by buying larger quantities from one supplier's complete line
8. Contribute to sales value of final product by using fasteners with a reputation for dependability and finish

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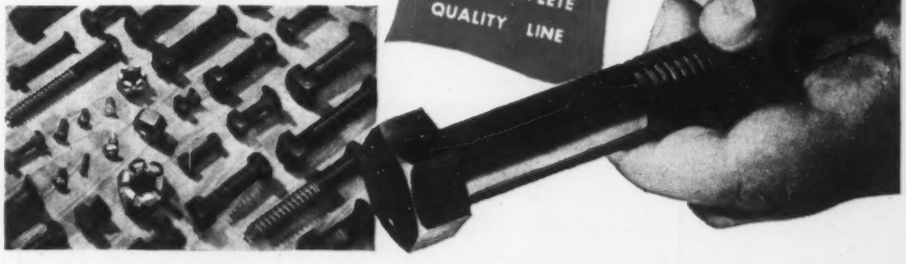
102 years making strong the things that make America strong

RB&W bolts, nuts, screws, rivets and allied fastening products are manufactured in a broad range of styles, sizes and finishes.

• • •

Plants at: Port Chester, N. Y., Coraopolis, Pa., Rock Falls, Ill., Los Angeles, Calif. Additional sales offices at: Philadelphia, Detroit, Chicago, Chattanooga, Portland, Seattle. Distributors from coast to coast. By ordering through your distributor, you can get prompt service from his stocks for your normal needs. Also—the industry's most complete, easiest-to-use catalog.



ers are treated with Superex, a nonflammable synthetic capacitor impregnant and have excellent energy-storage to weight ratio. They have heavy internal leads to carry high discharge currents, low inherent inductance, and are of special construction to minimize discharge stresses. Manufacturer: Solar Mfg. Corp., 285 Madison Ave., New York 17.

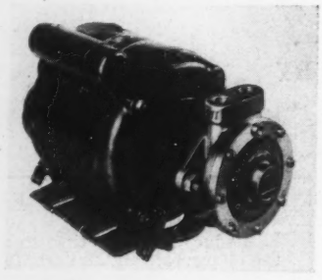
For further information circle MD 33 on card Page 239

Plug-In Type Relays

PLUG-IN TYPE RELAYS now being marketed weigh only 3 oz and measure but 1½ by 1½ by 1⅞-inches. Known as Series 41 relays their features include beryllium-copper armature and contact springs, low-reluctance air gap, as well as high-permeability and low residual-magnetism iron parts. Minimum input requirements are 20 milliwatts for dc types and 0.1 va for ac types. Contacts, which are single pole double throw, will handle up to 15 amperes on low voltage dc, or one kw incandescent lamp load at 115 volts ac. Manufacturer is the Sigma Instruments, Inc., 70 Ceylon Ave., Boston, Mass.

For further information circle MD 34 on card Page 239

Medium-Pressure Pump

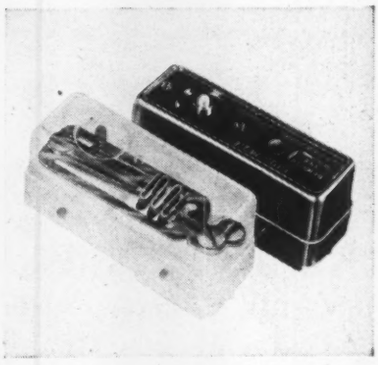


PUMP designed to handle variety of liquids in the medium flow and pressure field will pass liquid directly through the pump when not operating, without the need of a by-pass or relief valve arrangement. Model 4702 has a rotating impeller designed to hydraulically float in the housing, providing long life with little loss of flow or discharge pressure. Pumping water at room temperature, the capacity of the standard unit at 0 psi discharge pressure is approximately 100 gph. When the discharge flow is completely restricted, the shut-off pressure is approximately 200 psi. In general applications where 100 psi discharge pressure is required, flow is from 50 to 60 gph. While performances are based upon a shaft speed of 3450 rpm a 1725 rpm motor will provide 50 psi discharge pressure and a maximum of 25 gph. Manufacturer: Candler-Hill Corp., Division of Titan Pump & Engineering Corp., 405 Midland Ave., Detroit 3.

For further information circle MD 35 on card Page 239

Snap-Action Switch

COMPACT, SNAP-ACTION switch, designed to meet a need for a millibreak switch, provides uniform operating characteristics. The unit known as the Unimax has a moving member of heat-treated beryllium copper with tongue ribbed for maximum stability. It thus gains a uniform characteristic from the folded flat-spring section which provides high contact pressure and produces instant traverse. Nonrotatable actuator button assures application of actuating force to the same spot on tongue throughout life of switch. Contacts are silver, laminated on copper and moving contact has low mass for minimum contact bounce. Overall dimensions of the case are 1 15/16 by 11/16 by 13/16-inch. Electrical ratings



are 15 amperes at 125 volts and 5 amperes at 250 volts. All units are single-pole double-throw type. Manufacturer is the Unimax Switch Corporation, 460 W. 34th St., New York 1.

For further information circle MD 36 on card Page 239

High-Capacity Atomizing Nozzle

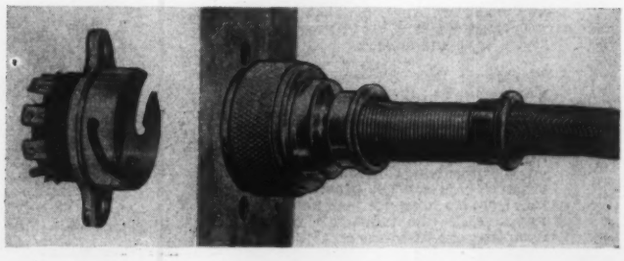
LARGE-CAPACITY pneumatic atomizing nozzle has capacities ranging from 20 to 60 gallons per hour. Built to operate from compressed air, steam or other gases, nozzles are of the internal mixing type and are made of brass and stainless steel. Units are available for ½-inch pipe connections. Manufacturer is Spraying Systems Co., 4023-F West Lake St., Chicago 24.

For further information circle MD 37 on card Page 239

Multiple Wire Connector

LOCKING shielded connectors for closing of circuits using up to 11 wires utilize a bayonet-joint connector and spring support of the cable. The connectors will accommodate cable up to ½-inch in diameter with maximum diameter of individual wires equal to 0.130 inch. They are weatherproof, sturdily built and provided with a projecting collar preventing prongs being touched as they become live in assembly. Manufacturer is the Alden Products Co., 117 North Main St., Brockton 64, Mass.

For further information circle MD 38 on card Page 239



VIBRATION — It's hidden... in high costs

Control it with

LORD

SHEAR TYPE

Bonded Rubber

MOUNTINGS

Right now—this minute—and in your plant . . . *you're losing money.* The cause . . . VIBRATION! You can't see it—it's hidden . . . but you can see vibration's costly results on your profit and loss statement . . . in high costs—directly attributable to industrial fatigue, lagging production, inferior accuracy, excessive scrap and shortened machine life.

Vibration can be controlled . . . and doing that you can raise your plant efficiency and morale, your product quality, and your profits. For immediate action, contact the nearest Lord Field Engineer or Lord direct. Let him analyze your product . . . in countless cases efficient application of Lord Vibration Mounts has surprisingly improved product performance. And ask him to check factory equipment . . . possibly a relatively simple solution can eliminate vibration, making your plant a better place to work—and a better working plant.

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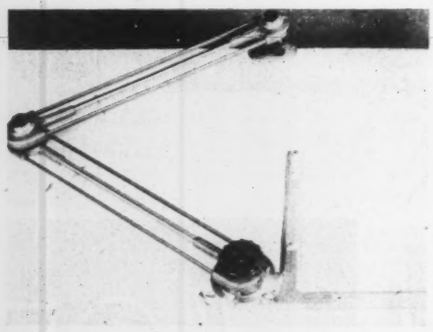
Drafting Machine

DRAFTING MACHINE features tubular band covers, excluding dust and dirt and improving appearance of machine. The Vemco machine has, in addition, metal brake

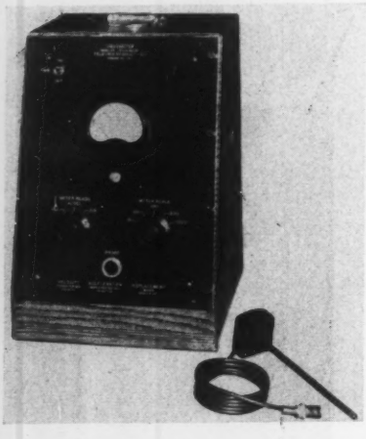


plates replacing plastic plates previously used. Other improvements of the machine include new metallic blue-green finish to reduce eye strain of user. Manufacturer: V & E Mfg. Co., 758 Fair Oaks Ave., Pasadena, Calif.

For further information circle MD 39 on card Page 239

Vibrometer

VIBROMETER with a frequency response of from 2 to 2500 cps has been developed by the Televiso Products Co., 7466 W. Irving Park Rd., Chicago 34. Known as Model 11-B, this vibrometer indicates all three com-

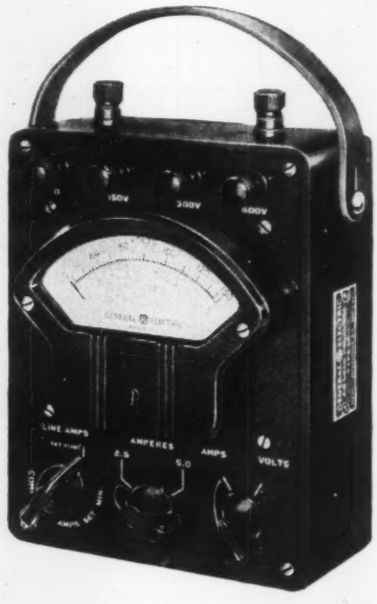


ponents of vibration measurement; displacement, velocity and acceleration. Pickup is a search prod connected through a cable to a receptacle on housing of instrument. Prod consists of an aluminum housing enclosing a piezo-electric crystal. Mechanical components of the instrument are housed in a solid-oak copper-lined cabinet measuring 17 inches high, 11½ wide and 12 inches deep. Five scales are provided for each vibration function with full-scale displacement range equal to: 0.01 to 1 inch rms; for velocity, 1 to 100 inches per second; 100 to 10,000 inches per second for acceleration. Accuracy is within 2 per cent over the range.

For further information circle MD 40 on card Page 239

Circuit Analyzer

ELECTRICAL INSTRUMENT known as load visualizer uses an iron-vane moving element and will serve as a standard ammeter and voltmeter. The instrument has been designed as a light-weight, low - cost analyzer for use on single-phase and balanced polyphase systems. Known as the AF-1, the visualizer has a current range of 0 to 2.5 and 5 amperes at 150, 300, 600 volts. It will also measure watts, vars, volt-amperes, and power factor for load surveys. Current winding in the instrument is electrically insulated from the imposed voltage by an internal double-current transformer. Current and voltage terminals are energized simultaneously from the line or through instrument transformers to extend the range. Manufacturer: General Electric Co., Schenectady 5, N. Y.

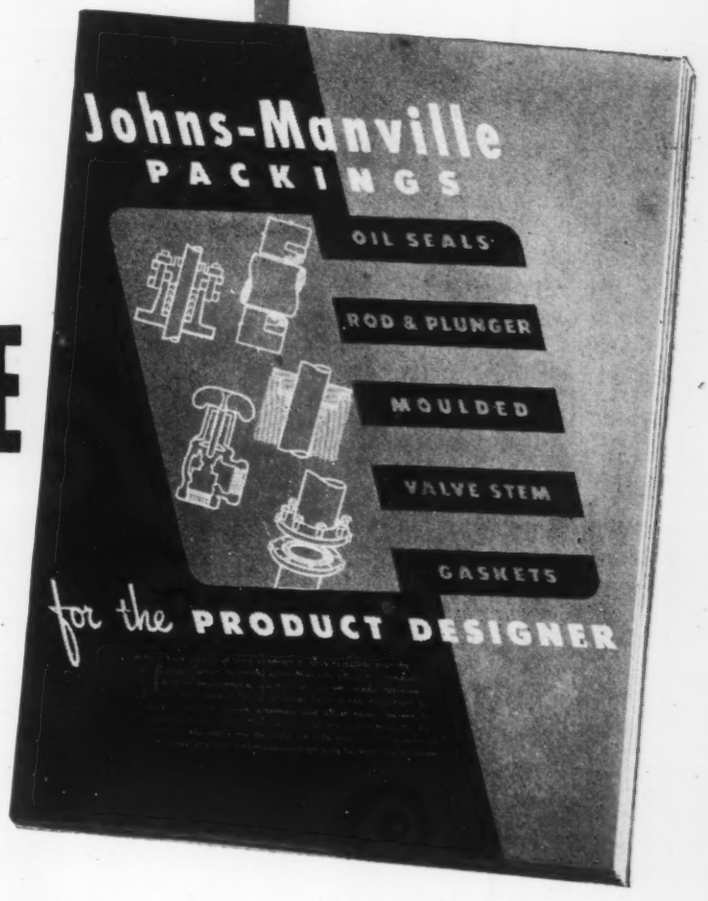


For further information circle MD 41 on card Page 239

Probe-Type Ohmmeter

POCKET-SIZED ohmmeter simultaneously serves as prod and has range of 0 to 10,000 ohms. Ohmmeter is enclosed in an attractive tubular - plastic case ⅞-inch in diameter and 5¾ inches overall. Prod-tip

Send for this *New* PACKING GUIDE



If you're looking for a packing that will help you simplify design, speed assembly or reduce production costs, here is a booklet you should have!

Prepared by J-M's engineering department especially for the product designer, it presents up-to-the-minute factual information about the Johns-Manville Packings listed below . . . packings that have become "standard equipment" with manufacturers of many types of products. It includes specifications, sizes and other data in handy tabular form to save time, simplify selection.

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J-M Die Formed Rings—precision manufactured to insure perfect mechanical fit, speed product assembly.

J-M Kearsarge—the rod packing with the accordion folded center block that acts as a reservoir for the lubricant.

J-M Flexible Metallic Packings—both all metal and semi-metallic packings for high speeds, pressures and temperatures.

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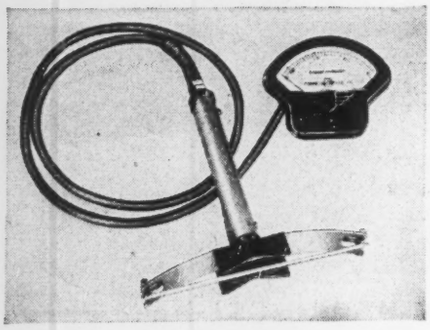
base and top cap, constructed of green molded Bakelite, are mounted in a transparent cellulose-acetate tube which houses the meter. Direct readings between 0 and 10,000 ohms on a 1.5 milliampere full-scale sensitivity Weston meter in series with a 1000-ohm molded-carbon resistor and a standard pen-light dry cell. Test electrodes include a stainless-steel prod built into the meter case and another secured to the tip of a 17-inch test cord. Manufacturer: Radio Tube Division of Sylvania Electric Products Inc., 500 Fifth Ave., New York 18.

For further information circle MD 42 on card Page 239

Pyrometer Kit

ADDED TO THE LINE of temperature testing instruments manufactured by the Pyrometer Service Co., 230 River Rd., North Arlington, N. J., is a new unit for obtaining accurate surface roll temperatures. The new instrument, known as RollTemp, is essentially a surface pyrometer with the indicating instrument separated from the thermocouple. Thermocouple is pressed lightly against hot surface and an instantaneous temperature reading is



obtained on the dial. Diameter of the heated surface determines the size of the thermocouple spacing plate, and the unit must be specified accordingly.

For further information circle MD 43 on card Page 239

Developing Tray

VERTICAL DEVELOPING TRAY for developing and fixing photographic and photocopy papers has 2 compartments, one for developing and one for fixing. Tray eliminates need for operator putting his hands into chemicals, print being put in a clamp and lowered into the developer where it is fully visible. Unit handlles prints up to 9 by 15 inches in size and measures 15½ inches long by 10 inches high by 5 inches deep. Manufacturer: Pronto, Inc., 845 Chicago Ave., Evanston, Ill.

For further information circle MD 44 on card Page 239

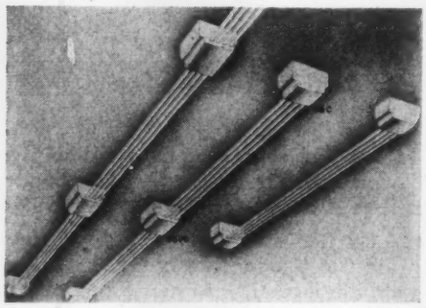
Timer-Controller

ELECTRIC POWERED TIMER controller measures elapsed time and will handle 1000 watts at 115 volts 60 cycles. Rim-set dial gives accurate time setting from 1 to 75 seconds, and settings may be changed while exposure is being made. Hands and figures are luminous for darkroom visibility. Unit is provided with a triple receptacle for straight power output, switch, and control circuit. Manufacturer: Lancaster Photo Products, South Lancaster, Mass.

For further information circle MD 45 on card Page 239

Fluorescent Light

PRODUCTION has been announced by the Duro Test Corp., North Bergen, N. J., of a new, slim, fluorescent lamp featuring instant starting, 10,000-hour lamp life, and



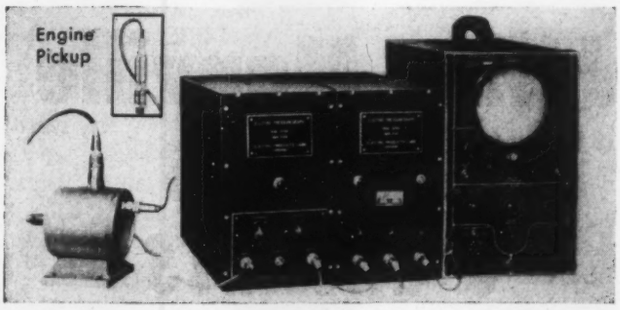
20 per cent light efficiency over cold-cathode lamps. The lamp is manufactured in standard eight-foot lengths and when used with the specified ballast is rated at 35 watts, 120 milliamperes. It features starting with no special starting equipment, is available in all standard colors, and operates singly or in multiple.

For further information circle MD 46 on card Page 239

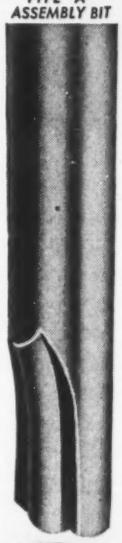
Time-Pressure Recording Device

RECENTLY-INTRODUCED pressure analyzing device known as the Syncro-Marker Pressuregraph reproduces on the screen of a cathode-ray oscillograph an accurate picture of pressures such as exist in internal-combustion-engine cylinders and relates the pressure variations to definite indicators of time, speed, etc. The instrument consists of four elements: Oscilloscope, syncro-marker, pressuregraph, and pickup. It will identify pressure variations as small as 1/4000-second transients. Manufacturer is the Electro Products Laboratories, 549 W. Randolph St., Chicago 6.

For further information circle MD 47 on card Page 239



TYPE "A" ASSEMBLY BIT



COMMON SCREWDRIVER

Yes! It's Just as Simple as That!

Reconditioning CLUTCH HEAD's Type "A" Bit Is Only a 60-Second Operation

MOREOVER, this simple operation can be repeated time, and time, and time again, to restore this rugged driving tool to its original efficiency. It involves only a 60-second application of the end surface to a grinding wheel.

This simple renewal cuts tool maintenance cost to a positive minimum

It definitely extracts the last vestige of service from each bit.

It does away with the expense and bother of "back-to-the-factory" shipments.

It multiplies again and again the number of screws driven per bit.

It smooths out assembly operation by eliminating delays . . . no waiting for returned bits.

Consider also, the longer uninterrupted service delivered by the rugged structure of the Type "A" Bit before reconditioning becomes necessary . . . its established record of 214,000 screws *driven in continuous operation* on the largest automobile assembly line in the world.

This is just one of the many exclusive CLUTCH HEAD *features contributing to lower costs through stepped-up production. Familarize yourself with all the advantages of this modern screw. Send for sample Type "A" Bit, package assortment of screws, and illustrated Brochure.*

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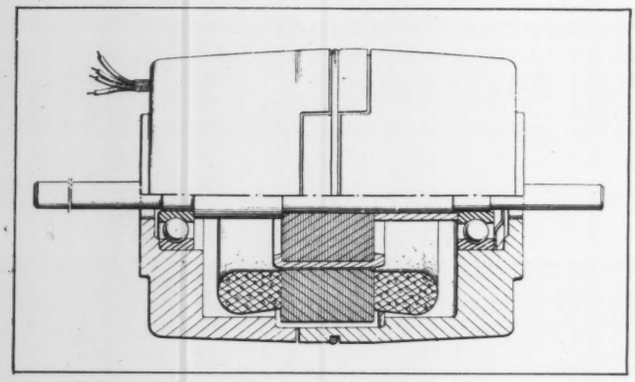
Noteworthy Patents

MAXIMUM EFFICIENCY in absorption of shock and vibration in shear as well as in compression is positively provided by the self-contained ball bearing covered in patent 2,414,335 assigned to Jack & Heintz Precision Industries Inc. by Herman C. Schroeder. Between the inner shaft ring of the bearing and the inner race is bonded a number of rubber rings. Likewise, the outer race is supported in an outer shell by a rubber ring on each side and peripherally, thus providing an overall resilient support which obviates transfer of vibration or shock to the balls.

KNOCKDOWN ASSEMBLY system obviating the use of screws, bolts, threaded parts, tools, or special equipment is outlined in patent 2,417,195 assigned to Bendix Aviation Corp. by William Hargreaves. Particularly suited to equipment such as power units, signal units, electrical

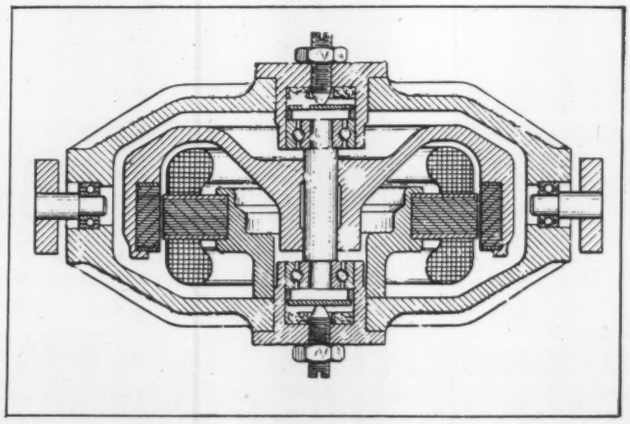


motors, generators, etc., which usually employ a housing or casing requiring considerable assembly work, often skilled, the particular design system covered employs a two-piece housing having interlocking fitted sections which can be assembled and held by a single snap ring.

FRICTIONAL SEALING by means of combined expansion and shrink fitting provides the only means for retaining the pressure within the hydraulic actuator covered in patent 2,414,492. Assigned to Urschel Engineering Co. by B. H. Urschel and L. H. Janzer, the cylinder is designed as a multipurpose unit and can be assembled in numerous arrangements. By employing outer rings which are heat-expanded and shrunk onto the cylinder ends at the same time the cylinder heads, cold-shrunk, are expanded into the ends, sufficient gripping force is produced to seal the cylinder leak-proof to well above 3000 psi.

CAM ACTION provides the control means for operating a fluid-flow selector valve covered in patent 2,415,446. Assigned to Curtis Automotive Devices, Inc. by Russell R. Curtis, the valve is applicable for the control of fluid flow from a number of sources of supply to a single delivery line, or vice versa. Operating somewhat similar to a group of swing check valves, the valve heads or disks are suspended on pivots and located in a circle. Operation of the cams by means of a suitable control handle positively opens one valve after another while holding the remainder closed.

SPIN AXIS moment of inertia of the electric gyro unit covered in patent 2,416,300 is large with respect to that of its transverse axis, the frame design being approximately elliptical in shape. To achieve these characteristics and provide for simplified assembly and repair, the rotor of the gyro revolves about rather than within its stator coils. Exceptionally sturdy rotor mount and bearing support are also obtained while the rotor construction results in a relatively high ratio of rotor weight to that of the frame, rotor and stator assembly. Assigned to Westinghouse Electric Corp. by Frank W. Godsey, Jr.



The size accuracy, surface finish and improved physical properties of Cold Finished flats make them applicable for many uses without extensive machining. They are economically made into slides for machine tools, parts for jigs and fixtures and molds for rubber and plastic. J&L Cold Finished flats are available in a variety of grades—in sizes from 6″ to 15″ from your nearest J&L Warehouse or distributor.

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Walter Ramberg

S. P. Timoshenko

MEN... of machines

RAYMOND B. TRIPP, who has been active in the affairs of the American Gear Manufacturers Association for a number of years, and for the past year serving as its vice president, has been elected president of the association. An executive vice president of the Ohio Forge & Machine Corp., Cleveland, Mr. Tripp has been associated with this organization for practically all of his business career. He started in 1913 as its purchasing agent, and soon became connected with the sales end of the company's activities, where he remained from that time until his election this year as executive vice president.

WALTER RAMBERG, who has directed the National Bureau of Standards aeronautical research program since 1937, has been appointed chief of the engineering mechanics section of the bureau. Dr. Ramberg succeeds H. L. Whittemore, recently retired after twenty-nine years' service at the bureau. Well known for his outstanding work in aeronautical research, especially in the field of aircraft structures, he has contributed extensively to scientific literature on the strength of materials, strength and instability of structural elements of aircraft, and the vibration of propellers. The most recent of a number of vibration measuring instruments developed by Dr. Ramberg is an electronic tube known as a vacuum tube acceleration pickup, designed to record rapidly changing accelerations of portions of an airplane in flight and now proving useful to the Army and Navy in studies of accelerations imposed on pilots in crash landings. Dr. Ramberg, who was born in Italy, came to America in 1920. After receiving his bachelor of science degree from Cornell in 1926, he worked for two years as an electrical engineer with the Westinghouse Electric Corp. He then went to Germany where he received his doctorate of science degree in 1930. A year later he joined the staff of the Bureau of Standards as physicist in the engineering mechanics section and has been in charge of the aircraft structures group since 1937.

STEPHEN P. TIMOSHENKO, professor emeritus of theoretical and applied mechanics at Stanford University, recently was awarded the James Watt International medal, one of the highest international honors, by the Council of the Institution of Mechanical Engineers of Great Britain. Dr. Timoshenko and the late Henry Ford are the only Americans who have received the medal. In addition to the James Watt medal, Dr. Timoshenko is a recipient of the Worcester Reed Warner medal, presented to him in 1935 by the American Society of Mechanical Engineers, and the Lamme medal in 1939, presented by the Society for the Promotion of Engineering Education. Born in Russia in 1878, he obtained his engineering education at the Institute of Ways of Communication, St. Petersburg, from which he graduated in 1901. After some years of study and travel, he accepted the chair of applied mechanics at the Polytechnic Institute in Kiev, and subsequently was elected dean of the School of Civil Engineering at the

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institute. In 1913 he returned to the Institute of Ways of Communication where he remained until 1918. Two years later he joined the Polytechnical Institute at Zagreb, Yugoslavia. In 1922 the Vibration Specialty Co. induced him to come to the United States as its consulting engineer. Subsequently he joined the research staff of Westinghouse Electric Corp. His love of teaching and his desire for leisure to devote to scientific writings led him to sever active connection with commercial work and to join the faculty at the University of Michigan, and later to come to the Stanford faculty. Dr. Timoshenko is the author of numerous technical books which have been translated into French, German and Russian.

♦

WILLIAM Q. DOUGLASS has become associated with the Mall Tool Co. as design engineer, resigning from the Diesel Engineering & Mfg. Corp., Chicago.

♦

G. TAYLOR STANTON has been appointed manager of engineering of Holtzer-Cabot division of First Industrial Corp., Boston. Mr. Stanton resigned from his position as chief engineer of TelAutograph Corp., New York.

♦

RUSSELL J. NADHERNY, formerly vice president in charge of engineering for Athey Products Corp., has been named chief engineer of Barnes & Reinecke. With twenty years of experience in the engineering field, Mr. Nadherny has been instrumental in the development of many new innovations in the heavy machinery field.

♦

GLENN B. WARREN succeeds Arthur R. Smith as managing engineer of General Electric's turbine-generator engineering division. Mr. Warren formerly had been design engineer in this division. Mr. Smith, who has been associated with the company since November, 1897, is retiring.

♦

W. B. PEIRCE, vice president in charge of research at the Flannery Bolt Co., Bridgeville, Pa., has been elected president of the American Society of Tool Engineers.

♦

FREDERICK V. H. JUDD, powerplant technical engineer of Republic Aviation Corp., has been honored for original research in aerodynamics by receiving the SAE Wright Brothers Medal for 1946.

♦

DR. GEORGE R. HARRISON, Dean of the School of Science, Massachusetts Institute of Technology, has been elected chairman of the American Institute of Physics. Dr. Harrison is author of the book, *Atoms in Action*, published in five editions in this country and translated into eight languages.

♦

C. W. DALZELL has been appointed chief engineer of Franklin Transformer Mfg. Co., Minneapolis. Mr. Dalzell formerly served as manager of engineering at Heyer Industries Inc., for twelve years. A member of AIEE, SAE and the Instrument Society of America, he has sixteen patents in the field of electrical engineering.

♦

DR. P. J. SELGIN, an expert in high-frequency radiation and electronics, has joined the staff of the National Bureau of Standards devoting his efforts to the development of electronic ordnance for the military services in the Ordnance Development Division. This division, established in 1942, serves as a research and development agency for the armed services in electronics ordnance and is the central unit within the bureau in the field of applied electronics.

♦

ELMER SCHNEIDER has been elected to the newly created position of vice president and director of engineering for Wheelco Instruments Co. He will take complete charge of engineering activities including inspection and approval of quality standards.

♦

THOMAS E. CUSHING, associated for over twenty-one years with the ball and roller bearing industry, has been made chief engineer. For the past five years Mr. Cushing supervised the engineering section handling the application of bearings to spindles and machine tools.

♦

DWIGHT M. WILKINSON, formerly chief engineer of Industrial Ovens Inc., is now president of Ovens for Industry Inc.

♦

I. E. COX, previously chief engineer of National Bearing Division of the American Brake Shoe Co., has been named vice president in charge of engineering. Mr. Cox has been connected with the company since 1935 when he joined it as research engineer.

♦

DR. MELVILLE F. PETERS has been appointed chief engineer of Titeflex Inc. He joined the firm in 1943 and at that time was placed in charge of research.

♦

CARROLL J. PEIRCE JR., chief of aerodynamics for the Boeing Airplane Co., has joined the Ohio State University school of aviation as director.

♦

J. J. MELLON, active in the development of industrial electric control equipment since his graduation from Rensselaer Polytechnic Institute in 1923, has been appointed chief engineer of Allen-Bradley Co. He has been with the company for two years and prior to this time has held important engineering and executive positions with Westinghouse Electric Corp. and Clark Controller Co.

♦

GEORGE N. SIEGER, president of S-M-S Corp., Detroit, has been elected president of the Resistance Welder Manufacturers Association in recognition of his outstanding co-operation, accomplishments and interest in the association's activities.

♦

ROY FARQUHARSON who has had more than twenty years of experience in designing tools, etc., has been promoted to the position of assistant chief engineer of Pioneer Engineering & Mfg. Co. He has been with the company for eleven years.

♦

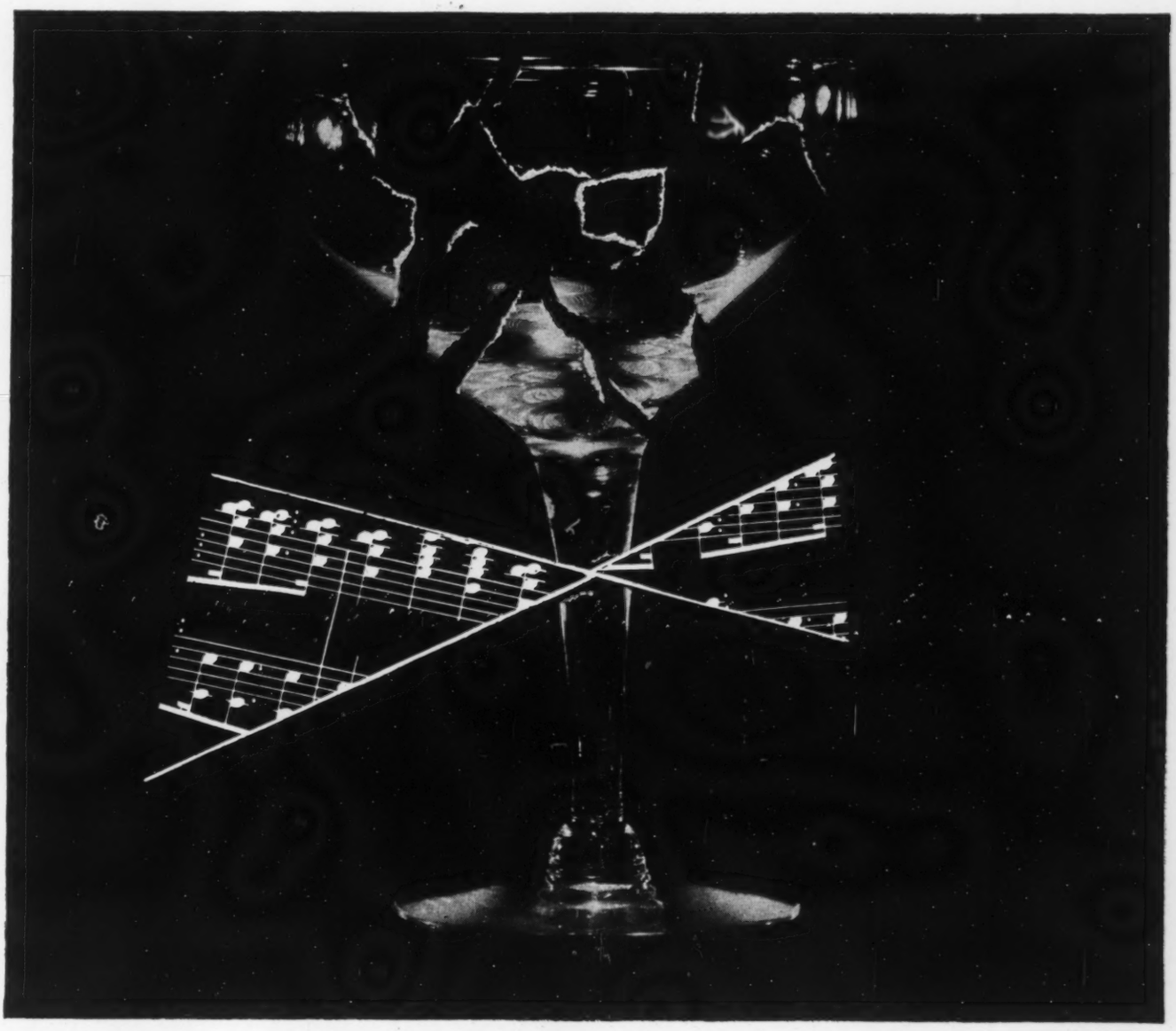
WILLIAM L. BATT, president of SKF Industries Inc., recently ended six and one-half years of service in the Federal government when his resignation as chairman of the Inter-Agency Policy Committee on rubber was accepted by the White House. Prior to his resignation, he received an award of the Medal for Merit from President Truman.

A FEW NOTES TO REMEMBER

It is possible to shatter a wine glass with a sustained musical note because the glass is too brittle to distribute the peak stresses that are set up by resonance.

For the same reason, failure can result in a brittle steel, with far more serious consequences than a mere broken glass.

One way to increase safety factor and to obtain many other advantages, is to specify temper-brittle-free molybdenum steels. These *modern* steels, which also provide good hardenability, good strength-weight ratio, and economy, are permitting many users to simplify—and save. Write for practical data.



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Design Abstracts

Making "Is" Equal to "Ought"

THE amazing variety of automatic devices used in aircraft, be they for engine control, comfort control, flight control, or navigation, operate in accordance with the same basic theory, called the "theory of servomechanisms". Now well understood, it is being continually elaborated as requirements become more complex and stringent. In essence, every control system has elements of inertia, resistance, and elasticity. Its position—to take the simplest case—is not exactly what it *ought* to be, the difference between what it ought to be and what it *is* being the *error*. Force is applied to the system, in a way depending on the measured error, to make *is* equal to *ought*.

An interesting analogy is the case of a large boy whose mother is leading him by the ear. The position he *ought* to be in is that of the hand that leads him. The *error* is measured by the stretch in his ear, and the consequent pain causes his legs to move. The smarter he is about moving his legs properly, the less will be the error-stretch in his ear. Therein lies the big problem of automatic-control design, to apply the correcting force in such a way that the difference between *is* and *ought* is always kept down to an acceptable amount.

In design, the same general procedures are always applicable—identify the inertial, resistive and elastive elements of the system and then give the force-controlling means enough built-in intelligence to produce the desired results.—*From a paper by Hugo Schuck and Gordon Volkenant, Minneapolis-Honeywell Regulator Co., presented at the recent National aeronautic meeting of SAE in New York.*

Endurance Strength and Processing

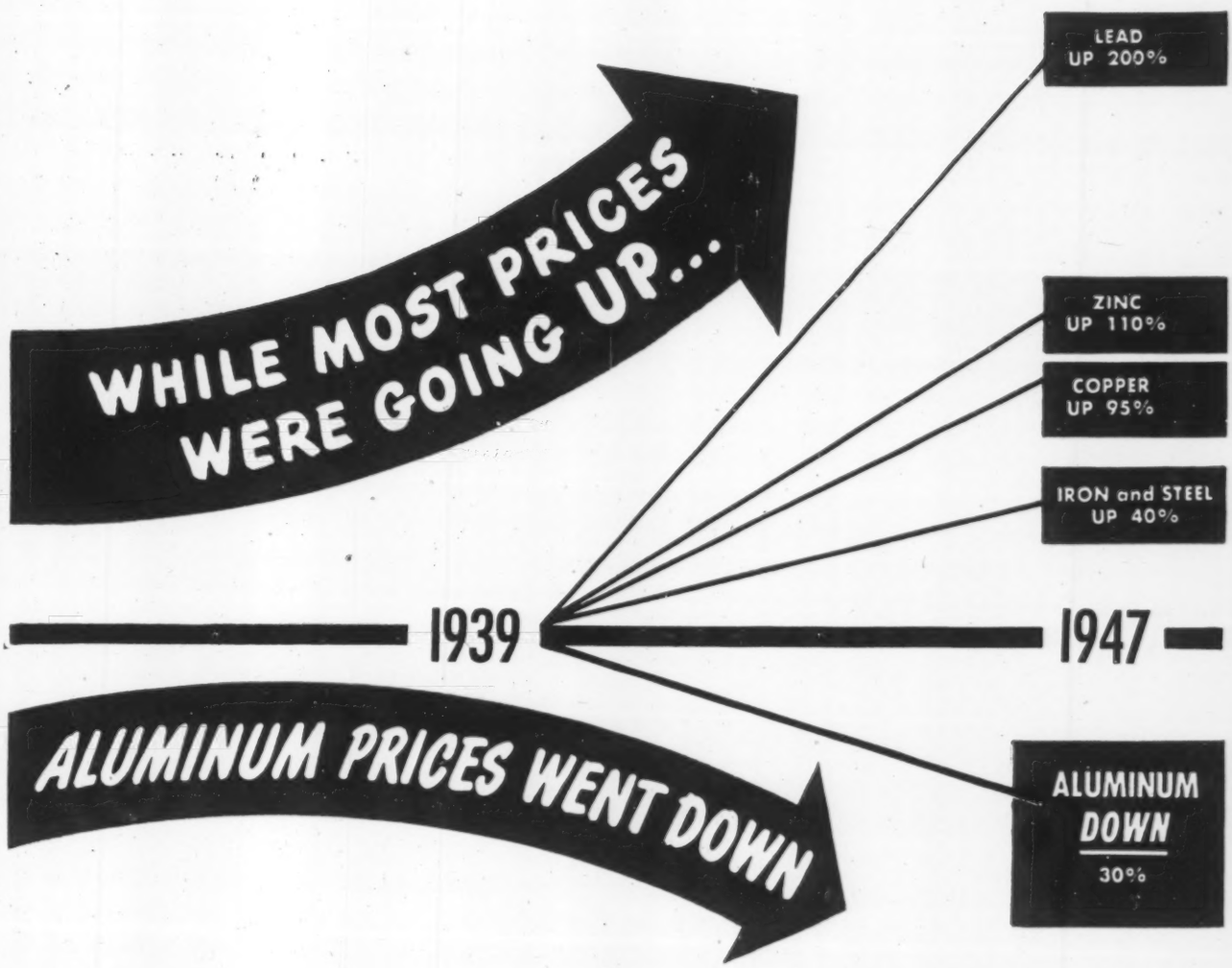
MATERIAL selection generally is based on tensile strength, yield strength, ductility, strength-weight ratio, rigidity-weight ratio, notch sensitivity, endurance limit, and, frequently above all, cost. While thousands of tables have been published on the physical properties of metals, the designer knows little about the *usable* endurance strength. Test bar values of "endurance limit" as determined by accepted laboratory techniques are often misleading; typical rotating-beam endurance values cannot be utilized in full-scale machine structures; the effect of size, geometry, surface finish, type of stress, temperature, residual stress, and source must be evaluated. Therefore the endurance strength of a material should be determined by running full-scale fatigue tests at elevated temperatures. Such tests indicate that the endurance strength of light-metal alloys as-fabricated run as low as 50 per cent of the rotating-beam endurance values. When the usable endurance strength of a material is accurately known, the endurance life of a structure can be predicted.

Endurance strength of most metals can be either increased or decreased through processing; yet the manufacturing processes to be used in the fabrication of a machine part generally are not specified by the design engineer, and processing is left up to the production department. Processing for high endurance strength is as important as the design itself, for a good design can fail if improperly fabricated. A stresscoat diagnosis of a crankshaft failure was made and a correlation with the fatigue failure obtained. The shaft had broken from a bending load; however, the tensile stress from a simulated engine load was not high enough to account for the failure. Vibratory strain measurements were made on the crankshaft under actual engine operating conditions and verified the static test results. The only possible explanation of the failure, then, was that the endurance strength of the material was greatly reduced through improper machining. The fatigue failure had occurred at a point where the machining marks were parallel to the maximum principal tensile strains in the shaft. Incipient failure was present before the shaft was placed in service. The process of shot peening prior to assembly could have "healed" the damage by placing the rough surface under a compressive residual stress. At present the production crankshaft is nitrided, thus obtaining maximum bearing life as well as maximum endurance strength. The design engineer *must* specify processing in order to control the endurance strength of the finished product.—*From a paper by W. T. Bean Jr., research engineer in charge of experimental stress analysis, Continental Aviation & Engineering Corp., presented at the forty-ninth annual meeting of ASTM.*

Street-Car Braking Improved

IMPORTANT improvements have been made in the braking system of the newer PCC cars. The cost, complication and maintenance of compressor, reservoirs, valves, piping and cylinders of the air-brake system seemed out of line with the small amount of work required for completion of the stop below the speed of dynamic fade-out, and for holding the car at stops. In addition, it had proved difficult to keep the brake levers and shoes of the air-operated wheel brakes from accumulating clearances due to wear, with consequent noise and rattles. These reasons led to investigation of other forms of supplementary mechanical brakes and all-electric operation has now been adopted as standard.

On this type of car the air-operated shoe brakes bearing on the wheel tread have been replaced by drum brakes carried on the coupling at the motor end of the driveshaft. Two forms of brake are in current production and use—an internal expanding and an external contracting. In either case, either of two forms of operating mechanism can be used—spring application and solenoid release, or solenoid application and spring release, with special means provided for spring application in case of failure of control power. This makes it possible to do away with the former hand brake for parking the car in



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sidings or yards as, with either form of brake or operating mechanism, opening the brake solenoid control circuit gives a spring-applied brake without battery drain.

While the original spring-solenoid brake was quite successful, it was felt that for general application as standard equipment for hilly as well as flat cities, a brake of greater holding power was necessary, and also that the drum brake should have sufficient thermal capacity for making the stop in case of failure of the dynamic brake. It seemed obvious that the drum brake would have the best chance of success in general application if its normal duty was reduced to the lowest possible level.

This led to the development of "extended dynamic" braking, wherein the dynamic brake is carried down practically to standstill, actually to about one mile per hour. Development was carried out with the cooperation of the engineers and staff of the Pittsburgh Railways Co. and has proven remarkably successful. Normal duty on the drum brake is thus limited almost entirely to holding at stops and, therefore, reduces the wear on shoes and drums to a point within the practical limits of a short-travel device like a solenoid.

Improvement has also been made in the "easy shut-off" by introducing resistance into the circuit before opening the line switch. This feature adds materially to passenger comfort during "on and off" operation behind slow traffic or with the nervous type of operator who, in spite of training and instruction to the contrary, will start and shut off two or three times while waiting for the traffic light to say "go".—*From a paper by S. B. Cooper, Westinghouse Electric Corp., presented at the recent winter meeting of AIEE in New York.*

Standards of Good Design Rising

A DESIGNER cannot work in a vacuum. He may know all about the theory of machines in general, but he cannot design a particular machine unless he knows how that machine can be built and all the circumstances attending its use.

Although design demands creative imagination, the industrial designer cannot let his fancy roam unchecked. Cold calculation plays an equally important part. The competition which supplies stimulus also imposes discipline. In the fine arts the designer (and a poet is only a designer of thought and word-patterns) need please only himself; in the applied arts, which constitute industrial design, he must please his customers and must consider not only their needs and tastes, but also their purses. Design, therefore, is a delicately balanced compromise between what is desired and what can be afforded by the prospective customer.

In spite of all this, we are surrounded by examples which show that good design is not only possible in a complex industrial structure, but that the standard of design is steadily rising. Our problem is to accelerate that process by increasing the number, skill and prestige of our designers. We must recognize potential talent and give it the opportunities and experience necessary for its development.—*From a paper by Sir Miles Thomas, Vice Chairman and Managing Director, Morris Motors, presented at the recent Conference on Industrial Design held in London, England.*

Cam Design

(*Concluded from Page* 148)

is necessary to have tables of the powers of integers, up to at least the 14th power. Fortunately, such tables are readily available at low cost°. By using the tables with an ordinary 8 or 10-bank calculating machine such as Friden, Marchant or Monroe, a cam can be calculated in a day or so. However, the complete process of cam design for an engine usually requires several weeks. This includes the gathering of numerical data on the particular engine, conferences with various engineers to determine the timing desired, calculation of a number of trial curves, making of plots, more conferences, etc. When suitable equations have been agreed upon, it is necessary to calculate the cam lifts at short intervals for at least two cam tracks. These must be checked for jumps, excessive accelerations, and numerical errors, and ramps provided at each end.

The tables mentioned do not provide all the powers needed for work at quarter-degree intervals. It is possible either to prepare special tables, as was done in some cases, or to change the variable and the coefficients so that only powers of integers are required. Suppose an equation is to be computed at 0.25 intervals of θ. By introducing a new variable $p = 4\theta$, or $\theta = p/4$, an equation is obtained in which only integral values of p will be called for.

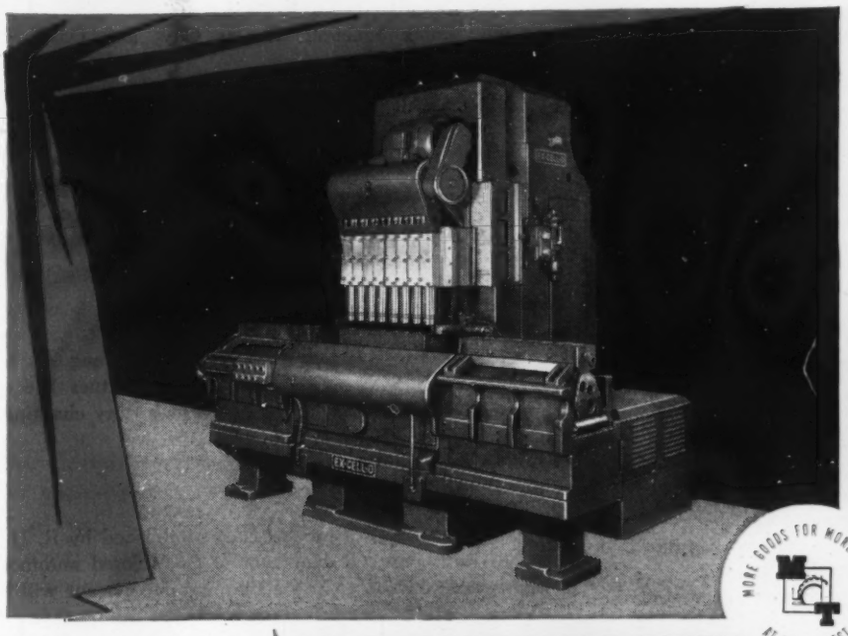
Checking for Errors

Final cam-lift values must be carefully checked for errors, as it is expensive to make master cams, and a wrong value may cause too deep a cut to be taken at the point. One checking method is to plot successive overlapping portions of the curve on a greatly enlarged scale, in which each small division of the graph paper represents 0.0001-inch of lift. Any value that is in error will lie noticeably off a smooth curve through neighboring points.

A quicker and more accurate method of checking is to take the first and second differences of the tabulated lifts. A mistake in one or more of the lift values will cause larger fluctuations in the differences. If both the first and second differences change smoothly and exhibit no peculiarities, the lift figures are probably correct.

About a year ago it was discovered that many of the routine calculations could be carried out semi-automatically on punched-card equipment of the International Business Machines Co. In several cases, the accounting department of Thompson Products Inc. has done the work with very satisfactory results. A typical cam requiring lift values at 70 to 80 points can be finished in three hours or less, the results arriving in a tabulated form printed automatically by the machines. It was not necessary to obtain any additional equipment for such work, and the regular accounting personnel handled all the planning and setup procedure after the problem was explained to them in general terms. Errors in the results are much less frequent than when computing and copying "by hand" with an ordinary calculator; any mistakes are readily located by taking first and second differences.

° British Association for the Advancement of Science—Mathematical Tables, Vol. IX, "Table of Powers Giving Integral Powers of Integers", Macmillan, New York, 1940.



EX-CELL-O CYLINDER BORING MACHINES

Boring as a method of precision machining automotive cylinders is a pioneer development by Ex-Cell-O. Here is shown the latest Ex-Cell-O machine of this type, Style 66 Vertical. Can be used also for boring holes in other parts where accuracy of roundness and straightness is required. *See it at the Show!*

NEW IMPROVED THREAD GRINDER

This new Ex-Cell-O Style 35-A Precision Thread Grinder is hydraulically operated and electrically controlled. Accommodates single or multi-rib wheels, with diamond dressers or form crusher. Leads from 1 to 128 threads per inch obtained with standard change gears. *See it at the Show!*

Automatic TOOL GRINDER

Designed for fast conditioning of straight faces of carbide-tipped, stellite, and high speed steel cutting tools. Ex-Cell-O Style 40 Automatic Grinder is extremely economical for the conditioning of varying quantities of identical tools. *See it at the Show!*

XLO

EX-CELL-O *for* PRECISION

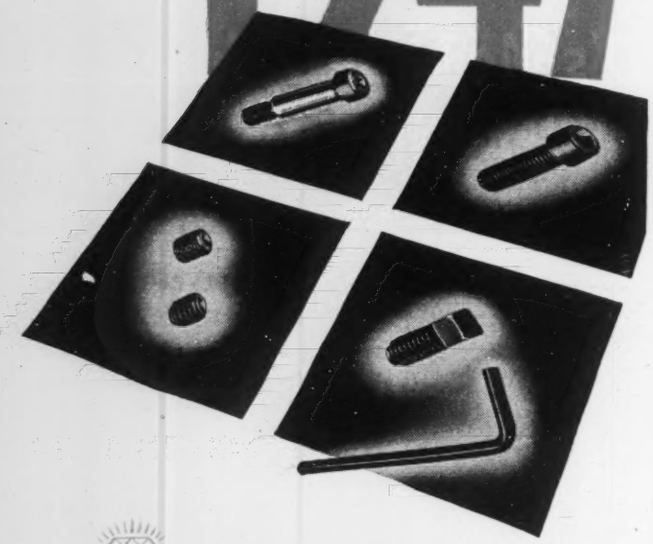
47—26

EX-CELL-O CORPORATION

DETROIT 6 MICHIGAN

MANUFACTURERS OF PRECISION MACHINE TOOLS • CONTINENTAL CUTTING TOOLS • MISCELLANEOUS PRODUCTION PARTS
FUEL INJECTION EQUIPMENT • RAILROAD PINS AND BUSHINGS • DRILL JIG BUSHINGS • DAIRY EQUIPMENT

1872
75 YEARS OF SERVING INDUSTRY
1947



OUR 75th ANNIVERSARY

1947 marks an important milestone in the history of The Chicago Screw Company, identifying it as a veteran leader in its field.

During its 75 years of progress, The Chicago Screw Co. has compiled a vast store of knowledge and skill that makes its products a standard of perfection in the screw fastening industry.

Apace with this growth in craftsmanship has been the constant addition of machines and tools to keep every process in Chicago Screw production the most modern known.

Chicago "Safety Plus" Socket Screws always represent the highest standard of quality. Outstanding in strength, clean and true dimensionally, "Safety Plus" fastenings are ideal for modern production methods.

Chicago "SAFETY PLUS" line includes:

Socket Head Cap Screws • Socket Set Screws • Stripper Bolts • Square Head Dog Point Set Screws • Socket Pipe Plugs • Keys for "Safety Plus" Products.

Complete line includes:

Hexagon Head Cap Screws • Square Head Cup Point Set Screws • Headless Set Screws • Fillister Head Cap Screws • Flat Head Cap Screws • Taper Pins • Milled Studs • Semi-Finished Hexagon Nuts • Semi-Finished Hexagon Castellated Nuts.

These Fine Products are sold only thru Authorized Distributors

THE CHICAGO SCREW CO.
ESTABLISHED 1872
1026 So. Homan Avenue Chicago 24, Ill.

BUSINESS AND SALES BRIEFS

ASSOCIATED with the company for twenty years, Ralph Best has been elected vice president in charge of sales of The Peerless Electric Co., Warren, O. For many years he served as manager of motor sales.

♦

Sola Electric Co. is now completely housed in its own building at 4633 West Sixteenth St., Chicago 50. The new plant was specifically designed to provide greater engineering, research and production facilities.

♦

Increased sales and service representation in the following areas has been announced by The Vascoloy-Ramet Corp., North Chicago, Ill.: B. J. Naden, Cleveland; J. M. Kinney, Toledo; Frank Scheffler, Kansas City; and Dean R. Cline, Chicago.

♦

Howard S. Thompson has been named assistant vice president in charge of sales promotion for The Commercial Shearing & Stamping Co., Youngstown, O. Succeeding him as manager of pressed steel sales is John E. Wallis, who formerly served as assistant manager of pressed steel sales.

♦

With headquarters in Cleveland, Frank Young has been appointed Ohio district manager for The Hertner Electric Co., manufacturer of motors, generators and battery charging equipment.

♦

A research department has been established by R. D. Fageol Co. to further the development of undisclosed automotive devices. An addition to house the new department will be completed shortly at the main plant on Mt. Elliott Ave., Detroit.

♦

Election of J. E. Workman as vice president in charge of sales has been announced by Latrobe Electric Steel Co., Latrobe, Pa.

♦

Selenium Corp. of America is now located at 2160 East Imperial Highway, El Segundo, Calif. The new building provides more than 32,000 square feet of floor space.

♦

In addition to his present position as general sales manager in charge of sales and advertising, David Blair Jr. has been elected vice president in charge of marketing for Telechron Inc., Ashland, Mass.

♦

A production plant has been opened in Stirling, N. J., by Sound Apparatus Co., designer and manufacturer of Graphic

OF VALVE-EQUIPPED PRODUCTS... A NEW AID

If the design and development of your product involves the choice of valves, you'll want this new Designers' Kit offered by Jenkins Bros.

It's a handy file of reference material especially selected for product development men. It will save you time whenever you need to answer the question, "*Which* type of valve *where* for best performance?" And from the information included, you'll see why Jenkins Valves are your logical choice for installation on any product.

First, you profit by Jenkins long experience in supplying valves for all types of products in which fluid control is a function of operation. Second, you can add the valve know-how of Jenkins Engineers, whenever necessary, to your own designing skill.

Most important, you gain a definite sales advantage by enlisting the established customer-confidence in Jenkins Valves, built up over 83 years by providing *extra value* in valves, and by continuous industry-wide advertising. Your prospects, noting your use of Jenkins Valves, will have confidence in an equally high quality of construction throughout your product.

Use the Jenkins Designers' Kit, and, when more help is desired, ask Jenkins Engineers to work with you on any problem of selection. Give your product, and its purchasers, the *extra value* of Jenkins Valves . . . *it costs no more.*

Jenkins Bros., 80 White Street, New York 13; Bridgeport, Conn.; Atlanta; Boston; Philadelphia; Chicago; San Francisco. Jenkins Bros., Ltd., Montreal.

Save time and trouble with this handy file of valve information.

JENKINS BROS. • 80 White St. • New York 13

Please send me Jenkins Designers' Kit.

Name_____

Company_____

Address_____

MAIL the COUPON

LOOK FOR THIS DIAMOND MARK

SINCE Jenkins Bros. 1864

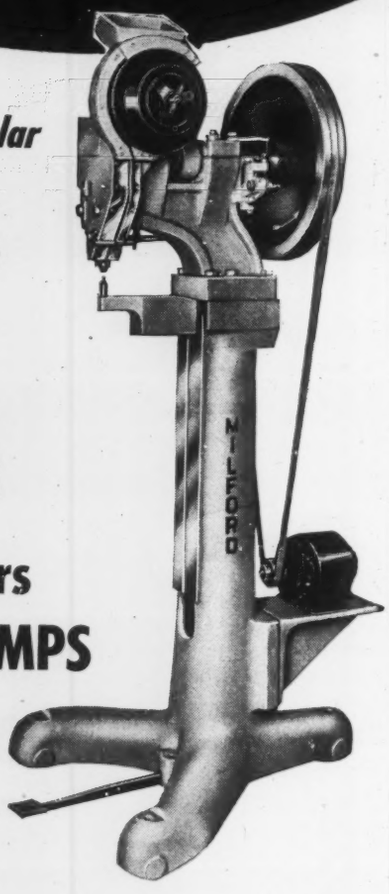
JENKINS VALVES

Types, Sizes, Pressures, Metals for Every Need

MILFORD FASTENING EQUIPMENT

MODEL No. 300-A

For EXTRA Heavy Duty



Sets semi-tubular or split rivets in such diverse assemblies as

WASHING MACHINES

Refrigerators

STEAM PUMPS

SKATES

CHAINS

SAWS, etc.

Here is another of Milford's 15 standard models of rivet-setters for assemblies ranging from wrist-watch bracelets to refrigerators. Every single Milford rivet-setter has more than paid for itself either in cutting costs of assemblies or in completing them faster. For any fastening need, check with Milford—for ideas to save time or cut costs.

THE MILFORD RIVET & MACHINE CO.
855 Bridgeport Ave. MILFORD, CONN.
996 West River St. ELYRIA, OHIO

Inquiries may also be addressed to our subsidiary:
THE PENN RIVET & MACHINE CO., PHILADELPHIA 33, PENNA.

Level recorders for acoustical and electrical measurements. The company's research laboratories are in Millington, N. J., and the main offices are at 233 Broadway, Woolworth Bldg., New York.

♦

Gibson Electric Co., Pittsburgh, has appointed J. H. Scott as sales representative, with headquarters at 823 Commerce Bldg., Rochester 4, N. Y. His territory will include Watertown and Binghamton, N. Y., as well as all of New York state west of these cities.

♦

Springs, wire forms, metal stampings and allied products will be produced by the newly formed Elyria Spring & Specialty Co., Elyria, O.

♦

Election of Bruce F. Olson as a member of the board of directors and vice president has been announced by the Pump Division of the Sundstrand Machine Tool Co., Rockford, Ill. Mr. Olson will retain his position as manager of the Pump Division.

♦

A branch plant has been opened in St. Thomas, Ontario, Canada, by the Timken Roller Bearing Co., Canton, O. John Jolly is general manager.

♦

Dave S. Ferree has been named by The Falk Corp. to serve as district manager of the new Philadelphia sales office at 505 Race St. His territory includes the Pennsylvania and Delaware areas formerly handled by Martell and Ferree, and the York, Pa., area previously managed by the late John Ericson.

♦

Election of Walter Geist to his sixth term as president has been announced by Allis-Chalmers Mfg. Co. All directors and officers of the firm have been re-elected.

♦

Operations have begun in a newly constructed plant of General Electric Co. at Anaheim, Calif. The new plant, a unit of the G-E chemical department, will manufacture Glyptal alkyd resins, basic ingredients for paints, enamels and other surface finishings. Heretofore production of the resins was confined to the company's Schenectady, N. Y., plant.

♦

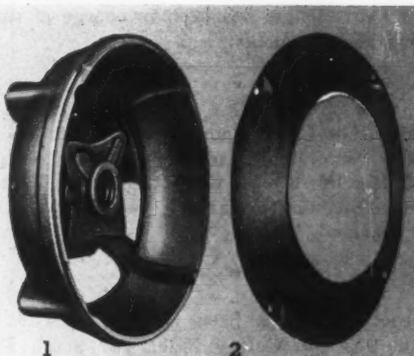
J. B. Ripley Brass Foundry of Windsor, Vt., has been appointed by Ampco Metal Inc. to serve as its licensee in the states of Vermont and New Hampshire. The Ripley organization will produce and sell Ampco Metal castings as well as stock and sell other copper-base alloy products.

♦

According to a recent announcement, Robert G. Cady has been appointed manager of the Materials Handling Division of the Ajax Flexible Coupling Co. Inc., Westfield, N. Y.

♦

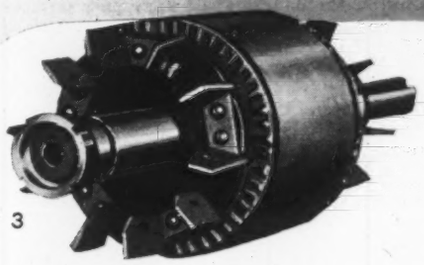
Connected with the company for twenty-eight years, Edward J. Helline has been named general sales manager of the Reliance Division of Eaton Mfg. Co., Massillon, O. For the



1 2

Century's Motor Ventilation System

✓Eliminates Hot Spots
✓Prolongs Insulation Life



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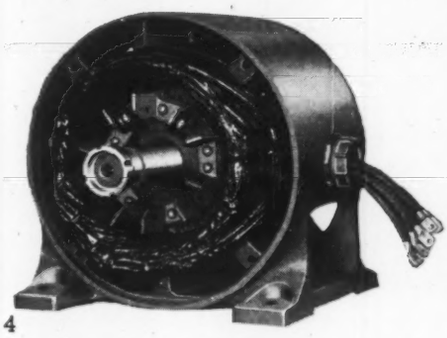

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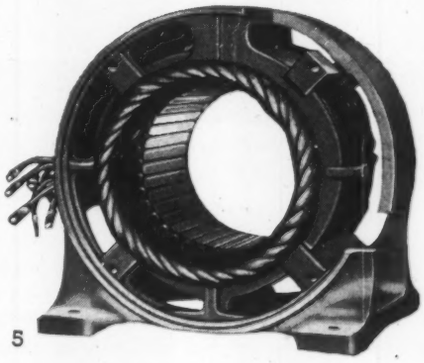

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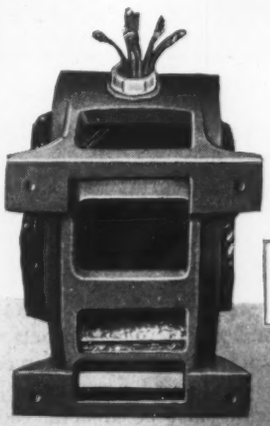


6

A blast of cooling air, forced through large smooth air passages, carries heat away from windings — eliminates the danger of hot spots, therefore, prolongs insulation life.

Two large fans bring air in through the end brackets, deflectors guide the air over the bearings, around the rotor, around the full circumference of the stator core, through the stator coil ends, across the outside of the stator core and out through holes at the side and bottom of the Form J squirrel cage induction motor.

These illustrations show, in detail, how the Century motor ventilation system helps to assure longer motor life by protecting the life of insulation —

1. Air intake is through large holes in lower half of end brackets. The upper half is closed to prevent dripping liquids and falling solids from dropping into the vital parts of the motor.
2. Deflectors in both end brackets guide the air to the center of the motor, around shaft.
3. Two large fans bring in air from both ends of the motor — across the ends of the rotor conductors — provides two-way ventilation.
4. Air is directed across the stator coil ends.
5. Maximum cooling is achieved by forcing air through large passages between the stator iron and the outside frame.
6. This view from the bottom of the motor shows how air is expelled from the passages at the side and bottom.

Be sure your electric motors have an adequate ventilation system to protect the insulation, and assure long motor life.

Century builds a complete line of electric motors and generators, fractional and integral horsepower, in the popular sizes to meet the requirements of industrial production, processing and appliance needs.

Specify Century motors for all your electric power requirements.

Century C MOTORS

532

CENTURY ELECTRIC COMPANY

1806 Pine St., St. Louis 3, Mo.

Offices and Stock Points in Principal Cities

HOW STOW FLEXIBLE SHAFTING

Helps You Milk a Maple.

● Illustration shows sugar bush tapping machine which can easily be carried on the back. It is driven by a ¾ h.p., 2 cycle gas engine, and equipped with a Stow 4-foot flexible shaft. The total weight of the outfit is about 31 lbs.

OR Solve a Tough Design Problem in Power Transmission

If you have power transmission problems involving angularity, varying levels of power and tool, related motion between power and driven element, then consider STOW FLEXIBLE SHAFTING!

Easily installed, STOW Flexible Shafting can be directed around obstacles, run at angles, and kept free-operating without binding. It eliminates costly gears, bearings and universals; simplifies assembly, where one quickly installed unit will slash hours off labor; saves hours of servicing by reducing mechanical complications.

STOW Flexible Shafting will do all this—combines lower cost with added profit on more units, due to mechanical design that gives your product distinctive sales appeal.

Send for informative book on power transmission and remote controls, via STOW Flexible Shafting.

STOW MANUFACTURING CO.
11 Shear St.
BINGHAMTON, N. Y.

past three years Mr. Helline has been in charge of snap ring sales engineering and production.

♦

Owens-Illinois Glass Co. has announced that its recently acquired subsidiary corporation, The Kimble Glass Co., hereafter will be operated as the Kimble Glass Division, with the present management remaining in charge. General offices will be maintained at Vineland, N. J.

♦

A new district office has been opened by The Electric Products Co. at 915 Old Colony Bldg., 407 South Dearborn St., Chicago. Robert R. Kovach is Chicago district manager and will be responsible for handling all sales and service negotiations in the territory.

♦

Vascoloy-Ramet Corp. has appointed W. T. Fink, president of Form Products Co., Minneapolis, to serve as distributor in the Minnesota area. Assisting Mr. Fink in developing a complete stock and service of VR Carbide and Tantung tools will be George Jalma, VR service engineer and factory representative.

♦

Change in location of the East Coast office has been announced by Adel Precision Products Corp., manufacturer of hydraulic equipment. J. P. "Bud" Barker, Eastern sales manager, will now be located at 77 Bedford St., Stamford, Conn.

♦

All-State Welding Alloys Co. Inc., White Plains, N. Y., has named Richard T. Spear as regional sales manager for the company's line of low-temperature welding and brazing alloys and fluxes. His territory includes eastern Pennsylvania, southern New Jersey, Virginia, West Virginia, Delaware, Maryland, and the District of Columbia.

♦

According to a recent announcement, G. Rider Neff and Frank G. Kaufman have been named vice presidents of Cleveland Cap Screw Co., Cleveland.

♦

Air Reduction Sales Co. has appointed H. C. Wallace to succeed the late R. S. Moore as manager of the Louisville, Ky., district. Prior to his appointment Mr. Wallace was assistant manager of this district. He now will be responsible for operations of all plants and offices in the Louisville territory which covers the states of Kentucky, Tennessee and part of Indiana.

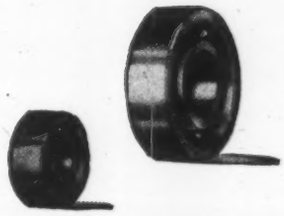
♦

Carroll D. Hepler, vice president, has been placed in charge of all sales activities of Trumbull Electric Mfg. Co., Plainville, Conn.

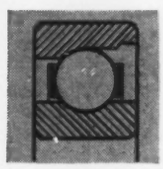
♦

Consolidation with Modern Tools, Berlin, Conn., has been announced by the Yankee Precision Products Co., Hartford, Conn., designer and builder of electronic and mechanical gages, tools and equipment. Offices and manufacturing facilities will be located in the Berlin plant of Modern Tools, which will continue operation as a division of the Yankee company. Ed-

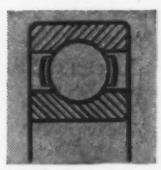
BEARING FACTS NUMBER 5



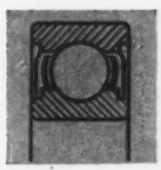
NORMA-HOFFMANN OFFERS DESIGNERS A WIDE RANGE OF PRECISION TYPES TO CHOOSE FROM



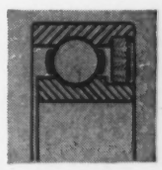
Separable, Magneto,—"E" Series.



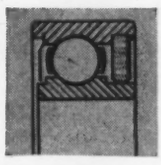
Extra Light—"D" and "S" Series.



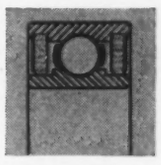
Single & Double Shield—"C-P," "C-PP" and "S-P," "S-PP" Series.



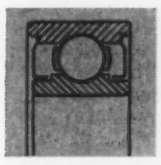
Felt Protecting Seal—"7000" Series.



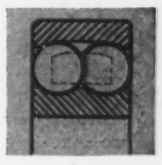
Felt Protecting Seal with Enclosing Shield—"7000P" Series.



Double, Removable, Felt Protecting Seals—"77000" Series.



Single or Double Flanged Metal Seal—"9000D" and "9000DD" Series.

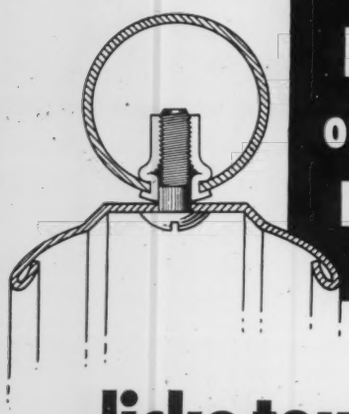


Double Row, Self-Aligning—"13300" Series.

Above are eight examples of the complete line of *small size* (under 1" O.D.) Ball Bearings by Norma-Hoffmann. They come in both inch and metric sizes down to ⅜ inch O.D. They are precision made to Norma-Hoffmann's standard of absolute uniformity. Backed by 35 years of experience, Norma-Hoffmann offers you one of the world's most complete lines of anti-friction bearings.

NORMA-HOFFMANN
***Precision* BEARINGS**

NORMA-HOFFMANN BEARINGS CORPORATION, STAMFORD, CONNECTICUT
FIELD OFFICES: New York, Chicago, Cleveland, Detroit, Pittsburgh, Cincinnati, Los Angeles, San Francisco, Seattle, Phoenix

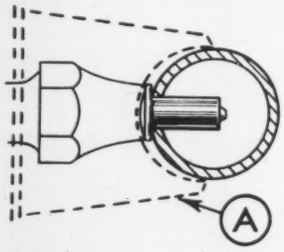


NEW USE of standard RIVNUT

...licks tough fastening problem

Designs for a new bicycle required a blind fastener which would serve as a nutplate for attaching a mudguard to the tubular frame. The head of the rivet had to conform to the curvature of the tubing. A *standard* flat head Rivnut solved the problem.

First, the correct radius was ground into the anvil of a standard heading tool. Guide "A" was added to insure correct curvature. The heading tool then formed the ring-shaped bulge and curved head of the Rivnut at the same time!



With its threads still intact, the Rivnut now provided a deeply-threaded nut plate for the mudguard attachment.

Perhaps Rivnuts will simplify your fastenings, reduce your costs. Why not consult a B. F. Goodrich Rivnut engineer?

▶ Authoritative load capacities in new "RIVNUT DATA BOOK"

Eccentric, tension, single and double shear load capacities of various Rivnuts are listed in the new, 40-page edition. Types, sizes and uses are also given. Fully illustrated, including step-by-step drawings of Rivnut installation. Write for your copy to The B. F. Goodrich Company, Dept. MD-77, Akron, Ohio.

B.F.Goodrich

RIVNUTS

It's a rivet—It's a nutplate

mond Morancey has been named to serve as general manager, and W. Krause as general sales manager.

♦

Facilities of The Summerill Tubing Co. will be merged with the parent company, The Columbia Steel & Shafting Co. The Summerill company will be moved from Bridgeport, Pa., to Carnegie, Pa., and it is expected that all equipment will have been transferred by the end of the year.

MEETINGS AND EXPOSITIONS

Aug. 21-22—

Society of Automotive Engineers Inc. West Coast transportation and maintenance meeting to be held at Biltmore Hotel, Los Angeles. John A. C. Warner, 29 West 39th St., New York 18, is secretary and general manager.

Sept. 1-4—

American Society of Mechanical Engineers. Fall meeting to be held at Hotel Utah, Salt Lake City, Utah. C. E. Davies, 29 West 39th St., New York, is secretary.

Sept. 8-9—

American Society of Mechanical Engineers. Second national conference of industrial instruments and regulators division to be held at Chicago. Additional information may be obtained from headquarters of the society at 29 West 39th St., New York. C. E. Davies is secretary.

Sept. 8-12—

Instrument Society of America. Second annual instrument conference and exhibit to be held at Stevens Hotel, Chicago. Richard Rimbach, 1117 Wolfendale St., Pittsburgh 12, is executive secretary.

Sept. 17-18—

Society of Automotive Engineers Inc. Tractor meeting to be held at Hotel Schroeder, Milwaukee. John A. C. Warner, 29 West 39th St., New York 18, is secretary and general manager.

Sept. 17-26—

National Machine Tool Builders' Association. Machine tool show and congress to be held at Dodge-Chicago plant of the Tucker Corp., Chicago. Tell Berna, 10525 Carnegie Ave., Cleveland 6, is general manager of the association.

Oct. 2-4—

Society of Automotive Engineers Inc. Aeronautic (fall) meeting and aircraft engineering display to be held at Biltmore Hotel, Los Angeles. John A. C. Warner, 29 West 39th St., New York 18, is secretary and manger.

Oct. 6-8—

American Society of Mechanical Engineers. Petroleum mechanical engineering conference to be held at Houston, Tex. Additional information may be obtained from headquarters of the society at 29 West 39th St., New York. C. E. Davies is secretary.

Oct. 18-24—

American Welding Society. Annual meeting to be held in conjunction with national metal congress and exposition at Sherman Hotel, Chicago. M. M. Kelly, 33 West 39th St., New York, is secretary.

Oct. 30-Nov. 1—

American Society of Tool Engineers. Fifteenth semiannual meeting to be held at Statler Hotel, Boston. Harry E. Conrad, 1666 Penobscot Bldg., Detroit 26, is executive secretary.

Hanna Valves

. . . put precise control of mighty muscles at your finger tips

Hanna Unitite Valves are designed and built to give long, trouble-free service. They are quick-acting, packless and permanently tight. Except for periodic lubrication they require no maintenance. They may be used as 3-way or 4-way valves operating at air, oil or water pressures up to 250 psi. for the ⅜", ½" and ¾" sizes; up to 150 psi. for the 1" size and up to 100 psi. for the 1¼" size. They are available in three different styles for standard mounting, column mounting or manifold mounting.

Foot-Operated Valves

● Hanna Foot Operated Valves are available in single and double pedal models for use at pressures up to 250 psi., air or oil.

Speed Control Valves

● Hanna Speed Control Valves provide adjustable control of inflow as well as outflow of air and oil independently to and from one side of cylinder piston. Available in a variety of sizes.

Valve Bulletin

● Bulletin No. 235 gives operating and mechanical data on all Hanna Valves. Write for a copy.

Hanna Engineering Works

HYDRAULIC AND PNEUMATIC EQUIPMENT . . . CYLINDERS . . . VALVES . . . RIVETERS

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Janette Speed REDUCERS

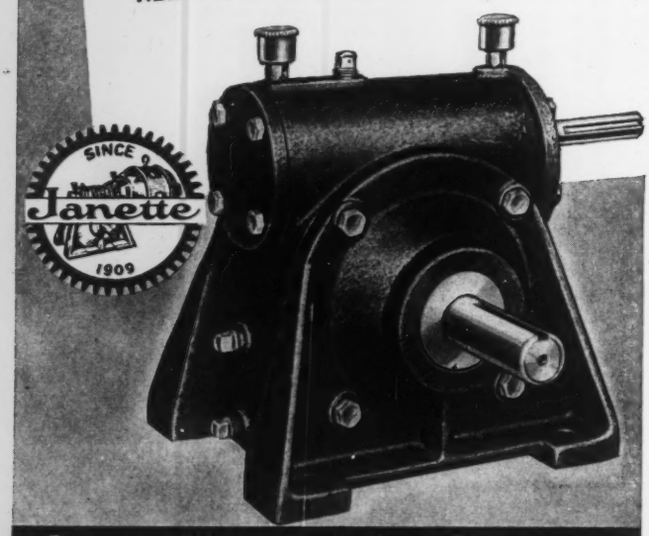
For SLOW SPEED DRIVES

1/20 to 7 1/2 H.P.
.08 to 450 R.P.M.

FOR OVER 37 YEARS Janette Has Been BUILDING HIGH QUALITY MACHINERY under the guidance of the founder of the company. We are small enough to be flexible, but able to take a personal interest in the individual requirements of our customers.

THE WORLD WIDE REPUTATION of Janette Electrical Machinery for reliable performance is, we believe, the equal of any company, large or small.

FOR THE MOST VITAL and IMPORTANT INSTALLATIONS You Can Safely RELY ON JANETTE SPEED REDUCERS!



Janette Manufacturing Company
556 W. Monroe St. Chicago 6, Ill.

NEW MACHINES

And the Companies Behind Them

Business

Automatic typewriter consisting of two units—an automatic paper-tape perforator operated in conjunction with an electric typewriter and an automatic typewriter operated from a tape-reading unit. Justowriter Corp., Rochester 1, N. Y.

Multipurpose console for voice-paging and music. Contains central control elements needed in sound system requiring up to 50 watts. Executone Inc., New York.

Ceramics

Glass-batch mixer. Has air-operated cylinder for discharge chute, and batch hopper gate controls. Industrial Div., Ransome Machinery Co., Dunellen, N. J.

Domestic

Vacuum cleaner with a self-adjusting nozzle measures rug pile and adjusts itself automatically. Premier Vacuum Cleaner Div., General Electric Co., Cleveland 14.

FM-AM radio-phonograph combination console. Has 9 tubes plus rectifier. Dimensions: 36 x 34 1/4 x 17 1/2 in. Radio Corp. of America, Camden, N. J.

Dry Cleaning

Moth-proofing unit embodying a filtering and charging tower fitted with cartridges containing DDT. U. S. Hoffman Machinery Corp., New York.

Excavating

Shovel payloader having 3/4-yd capacity and four-speed, fully-reversible transmission. Single lever shifts gears. Frank G. Hough Co., Libertyville, Ill.

Power shovel available both as crawler and wheel-mounted machine, as shovel, dragline, clamshell, crane, backhoe, and other combinations. The Osgood Co., Marion, O.

Finishing

Flexible-shaft machine for disk and drum sanding, drilling, wire brushing and polishing, as well as grinding. Aristo Power Tools Inc., Chicago 6.

Metal spray gun. Melts and sprays low-melting temperature alloys and metals (in the 100-600 F range). Metaloy Sprayer Co., New York 6.

Food

Popcorn vendor, coin-operated. Money actuated for measuring raw corn, popping and bag filling. Cycle takes about 75 seconds. Viking Tool & Machine Corp., Belleville 9, N. J.

Insectide sprayer, automatic. Operates on ac or dc current. West Disinfecting Co., Long Island City, N. Y.

Heating and power plant, oil-fired, for drying and storing perishable farm feed products. J. B. Beaird Co. Inc., Shreveport, La.

Semiautomatic, net-weight filling machine for dry products such as nuts, small vegetables, candies, etc. Weighs quantities up to 2 1/2 lb; handles containers from 1 to 10 in.

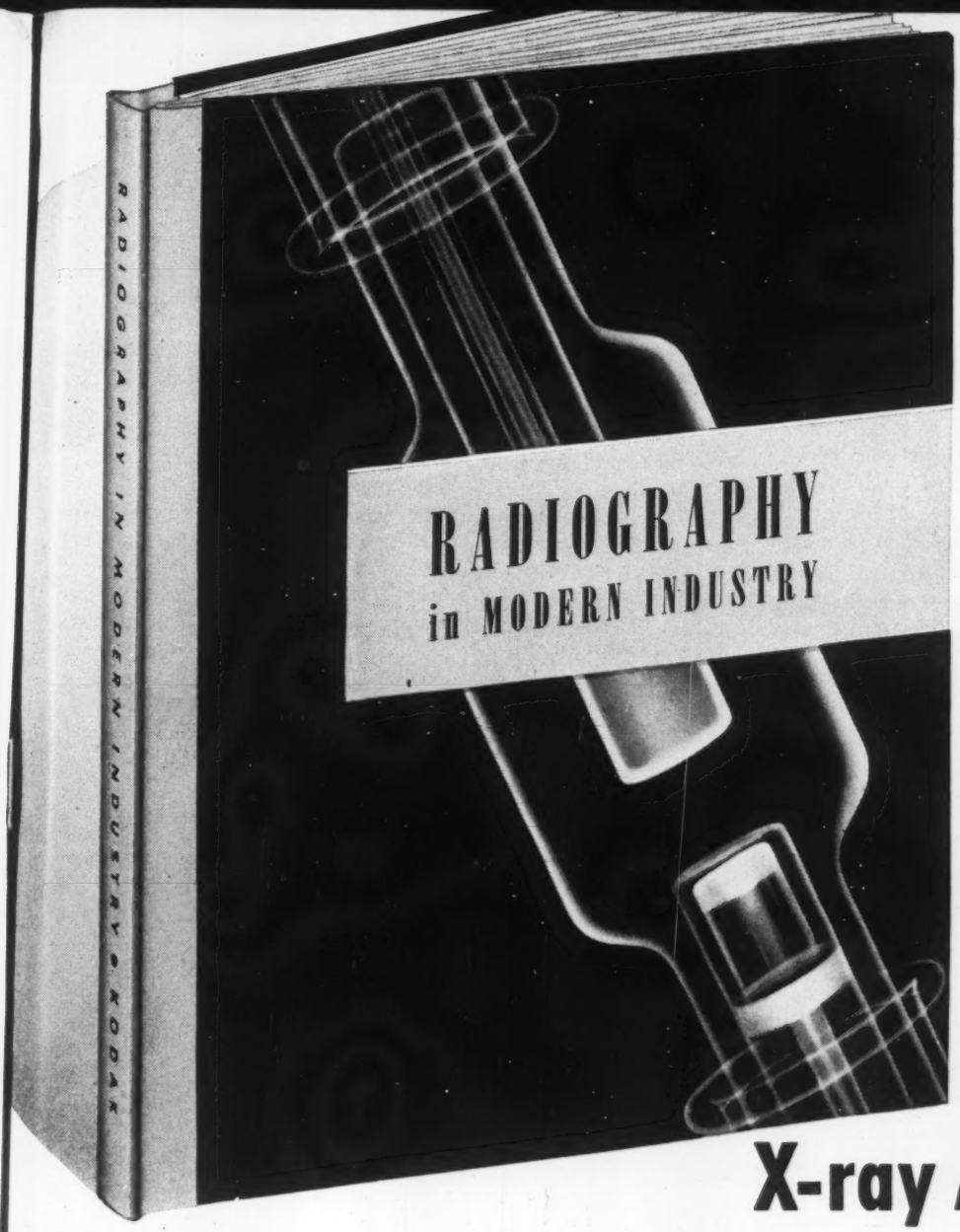
Water demineralizer. Operates at 60 gal per hr. Can be used to deliver water containing a maximum of 10 ppm of ionized solids or as little as 1 ppm. Ion Exchange Products Dept. of American Cyanamid Co., New York.

Pasteurizer for cheese milk at temperatures up to 190 F. Allows pasteurization at any temperature between 160-190 F, without formation of " milk stone" or "burn-on." Chester Dairy Supply Co., Chester, Pa.

Fat purifier for either batch or continuous fryers. Combines filtration and purification. Size available to purify 3 1/2 to 20 gal of oil per min. Honan-Crane Corp., Lebanon, Ind.

Heat Treating

Indexing table for use in soldering, brazing and annealing of



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Radiography... another important function of photography

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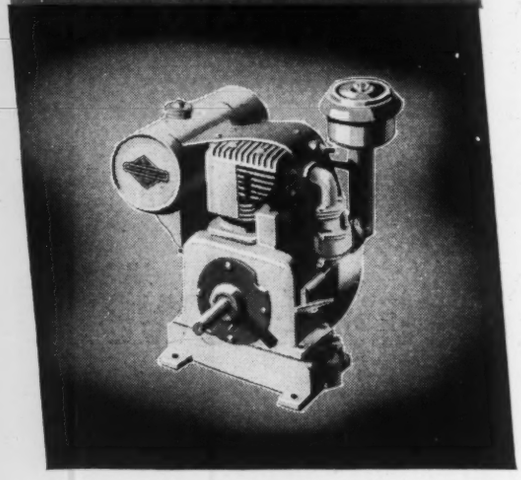
THREE MILLION

BRIGGS & STRATTON ENGINES

A NEW PEAK IN GASOLINE POWER HISTORY



When the 3 MILLIONTH Briggs & Stratton engine came off our production lines recently, a series of new records was established for the entire industry. It is by far the greatest number of 4-cycle air-cooled engines ever built by one manufacturer. It is by far the longest period . . . more than 27 years . . . that any manufacturer has built 4-cycle air-cooled engines *continuously, without interruption.* Back of these engines Briggs & Stratton maintains the most extensive, worldwide network of *Authorized Service Stations* in the small engine field.

Preferred Power FOR INDUSTRIAL CONSTRUCTION RAILROAD AND FARM EQUIPMENT

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Milwaukee 1, Wisconsin, U. S. A.

AIR-COOLED POWER — 4 CYCLE BRIGGS & STRATTON GASOLINE ENGINES

round or irregularly shaped small parts. Varied length of heating cycle. Lapel High Frequency Laboratories Inc., New York 23.

Electric pot furnace with working capacity of 275 lb in aluminum. Size: 49 3/4 x 37 1/4 x 44 1/8 inches. Pereny Equipment Co., Columbus, O.

Industrial

Fire protection unit having a high pressure portable pumping and fire fighting unit. Porto-Pump Inc., Detroit 7.

Heavy-duty vacuum cleaners with industrial cleaning tools and heavy-duty blowers. Ac or dc motor drive. General Electric Co., Bridgeport, Mass.

Instruments

Instrument for purifying and removing moisture from gases automatically. Baker & Co. Inc., Newark 5, N. J.

Electronic automatic sorting gage specially built to inspect for accuracy of diameter and length of fountain pen barrels. Federal Products Corp., Providence, R. I.

Automatic inspecting machine. Measures parts to close tolerances and segregates these parts. The DoAll Co., Des Plaines, Ill.

Lubrication

Industrial lubricating unit. Needs no air or electric connections. Has two 1-lb lever guns and 1/2-pt pistol oiler. Gray Co. Inc., Minneapolis.

Materials Handling

Pneumatic-tired fork lift truck for working outdoors and on surfaces too uneven for solid tired machines. Capacity: 4000 lb at 24 in.; a lift of 120 in. with 85 1/2 in. overall height.

Combination scale and dump truck for batching. Has 40 cu ft dump hopper. Yale & Towne, Philadelphia.

Metalworking

Hydraulic slotter with 36 x 48 in. stroke for heavy-duty work. Ram may be set in a vertical or tilted plane up to 15 degrees off vertical. Rockford Machine Tool Co., Rockford, Ill.

Automatic cycle centering machine and drilling heads. Klatt & Wood Co., Toledo.

Rubber

3400-ton two-opening, multiple-cylinder, hydraulic steam platen press for vulcanizing rubber composition sheet packing or floor tile. R. D. Wood Co., Philadelphia.

Bench-type guillotine cutter for cured or uncured rubber stocks of square, rectangular, round or irregular cross sections to length. Black Rock Mfg. Co., Bridgeport 5, Conn.

Restaurant

Insulated conveyor-type toaster. Capacity, 9-12 slices per min. Savory Equipment Inc., Newark 5, N. J.

Textile

Stainless steel "slack loop" washer. Processes goods up to 175 yd per min. Air-operated squeeze rolls. Textile Machinery Div., Rodney Hunt Machine Co., Orange, Mass.

Screen printing machine. Prints 2 to 15 colors in a single printing. Photomatic Service Corp., New York.

Horizontal padder, 3-roll, which becomes an extracting mangle, a caustic impregnator, a universal padder, or a starch mangle; or with a change of rolls a 15-ton rayon calendar. H. W. Butterworth & Sons Co., Philadelphia.

Welding

Portable gas-driven arc welder. Weight, 315 lb. Size: 32 x 26 x 28 in. National Cylinder Gas Co., Chicago.

Spot welders, pedestal type of 35, 50 and 75 kva capacities with low-inertia head for high-speed operation and quick adaptability to all kinds of welding. Progressive Welder Co., Detroit.

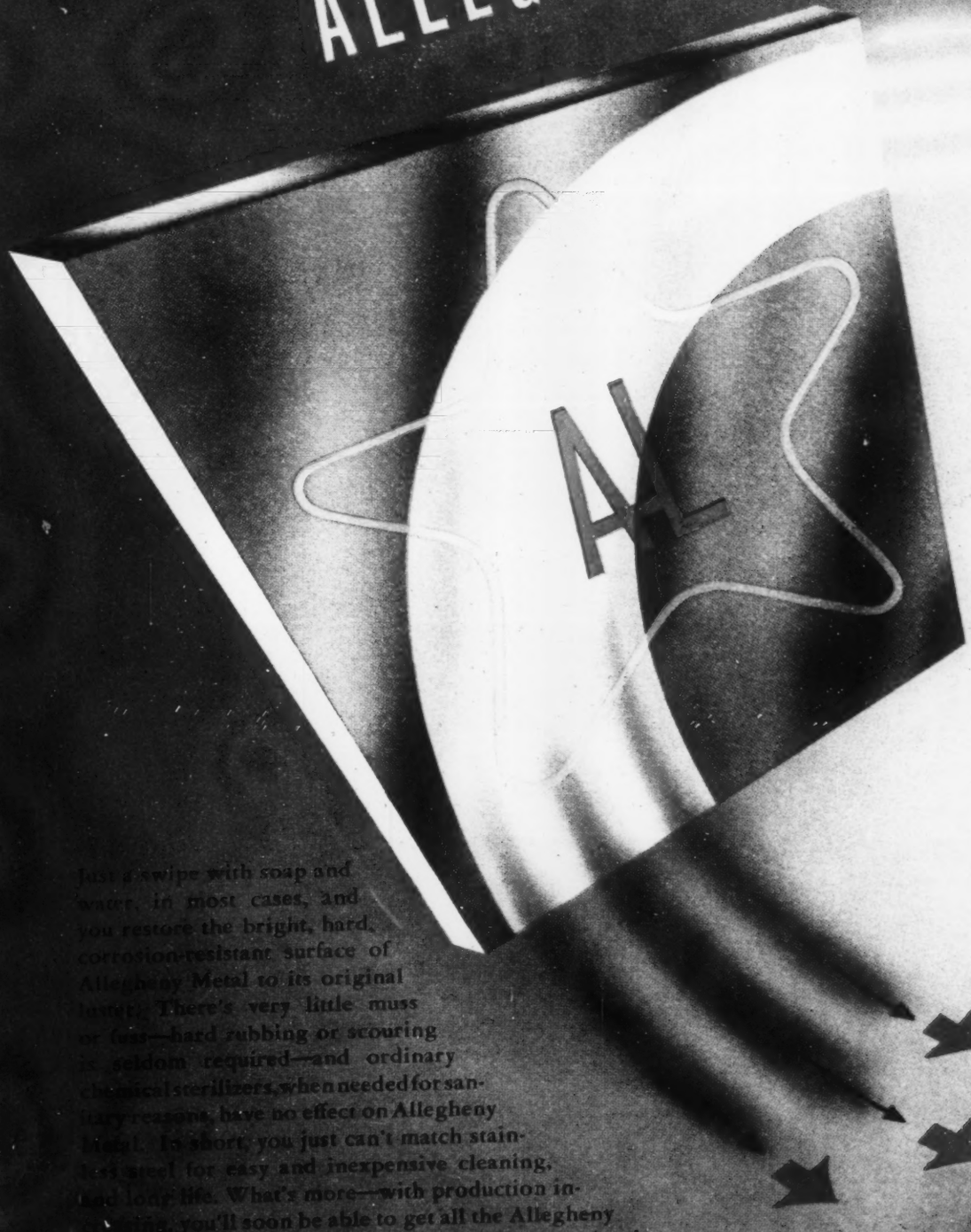
Woodworking

Automatic wood fabricators with adjustable tracks, for prefabrications of angular or curved assemblies. Muskegon Machine Co., Newburgh, N. Y.

Portable electric sander, Sterling Tool Products Co., Chicago.

for the lowest cleaning costs

ALLEGHENY METAL



Just a swipe with soap and water, in most cases, and you restore the bright, hard, corrosion-resistant surface of Allegheny Metal to its original luster. There's very little muss or fuss—hard rubbing or scouring is seldom required—and ordinary chemical sterilizers, when needed for sanitary reasons, have no effect on Allegheny Metal. In short, you just can't match stainless steel for easy and inexpensive cleaning, and long life. What's more—with production increasing, you'll soon be able to get all the Allegheny Metal you want. ● Let us help you now to plan ahead.

SALES SERVICE based on RESEARCH and DEVELOPMENT

ALLEGHENY LUDLUM STEEL CORPORATION, PITTSBURGH 22, PA.

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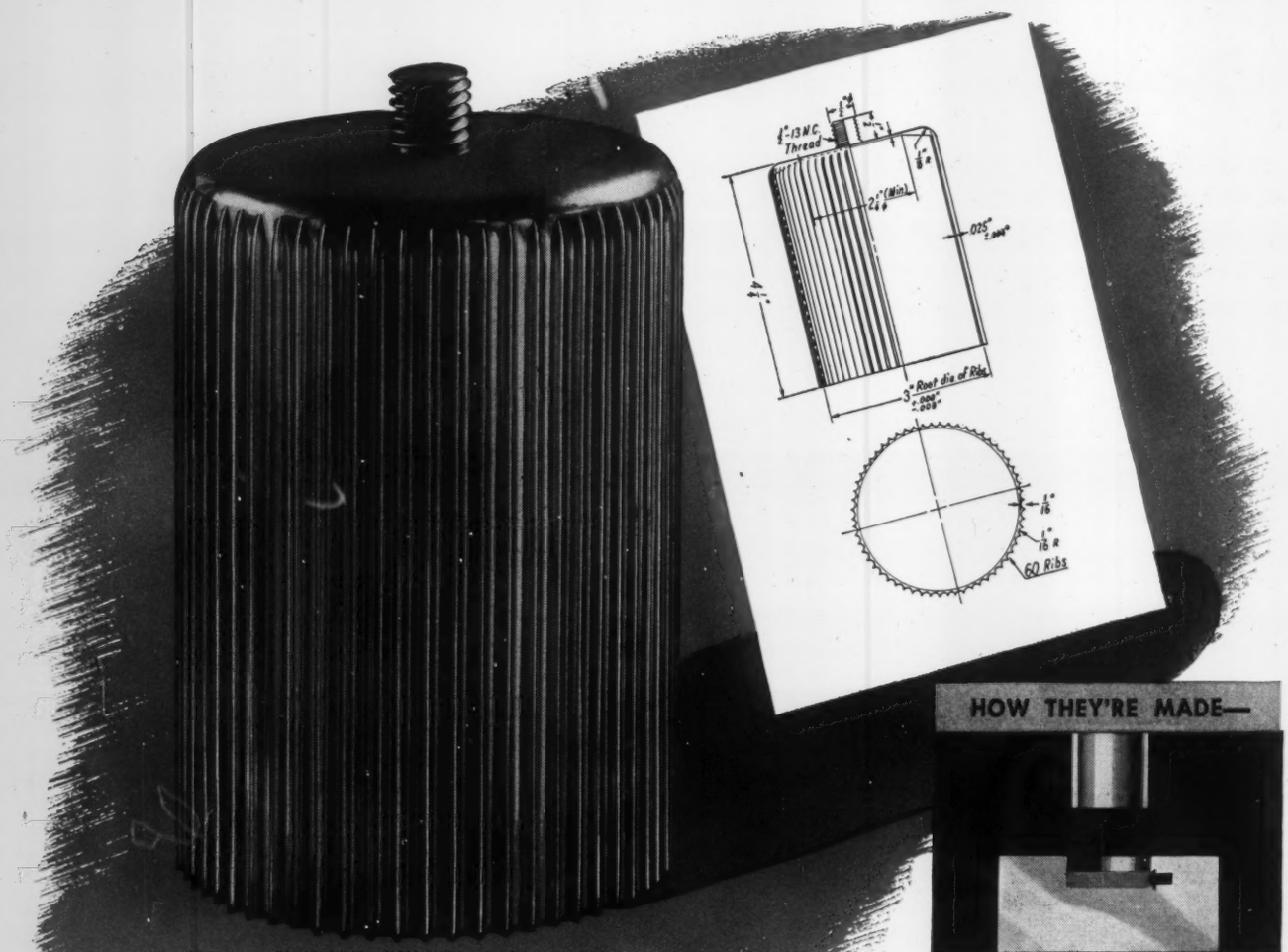
CALL FOR AN ALLEGHENY LUDLUM ENGINEER

ALLEGHENY METAL is stocked by all JOS. T. RYERSON & SON, Inc., Warehouses



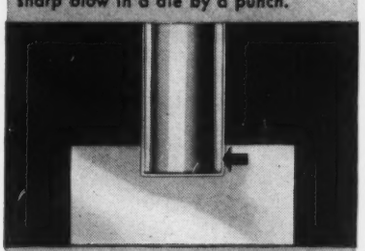
ONE WALLOP makes a BETTER Body for this container . . . At LOWER Cost

In the flick of an eyelash, a slug of Alcoa Aluminum is impact-extruded . . . walloped once . . . to form the cylindrical body of this container . . . complete with formed ribs and bottom stud ready for threading.

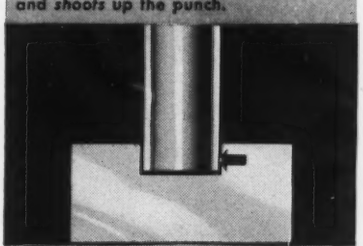
The impact extrusion process is ideal for the low-cost production of symmetrical parts that would require several forming operations if made by ordinary stamping, spinning, or drawing methods. And you have much greater leeway in special design features when you make it an impact extrusion. ALUMINUM COMPANY OF AMERICA, 1940 Gulf Building, Pittsburgh 19, Penna. Sales offices in leading cities.

HOW THEY'RE MADE—

1. A slug of aluminum is struck one sharp blow in a die by a punch.



2. Because the die is larger than the punch, the metal flows out of the die and shoots up the punch.



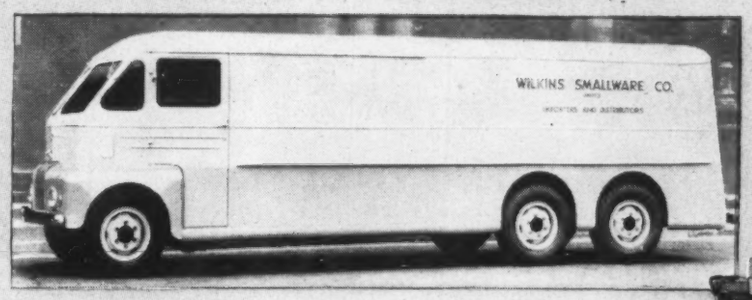
3. The space between the die and punch determines wall thickness. The external design features are incorporated in the die, the internal in the punch.

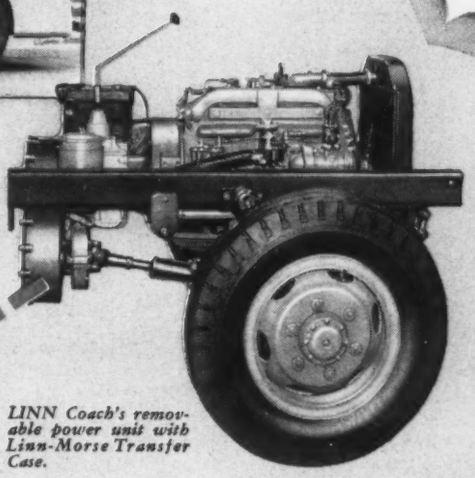
MORE people want MORE aluminum for MORE uses than ever

ALCOA FIRST IN ALUMINUM

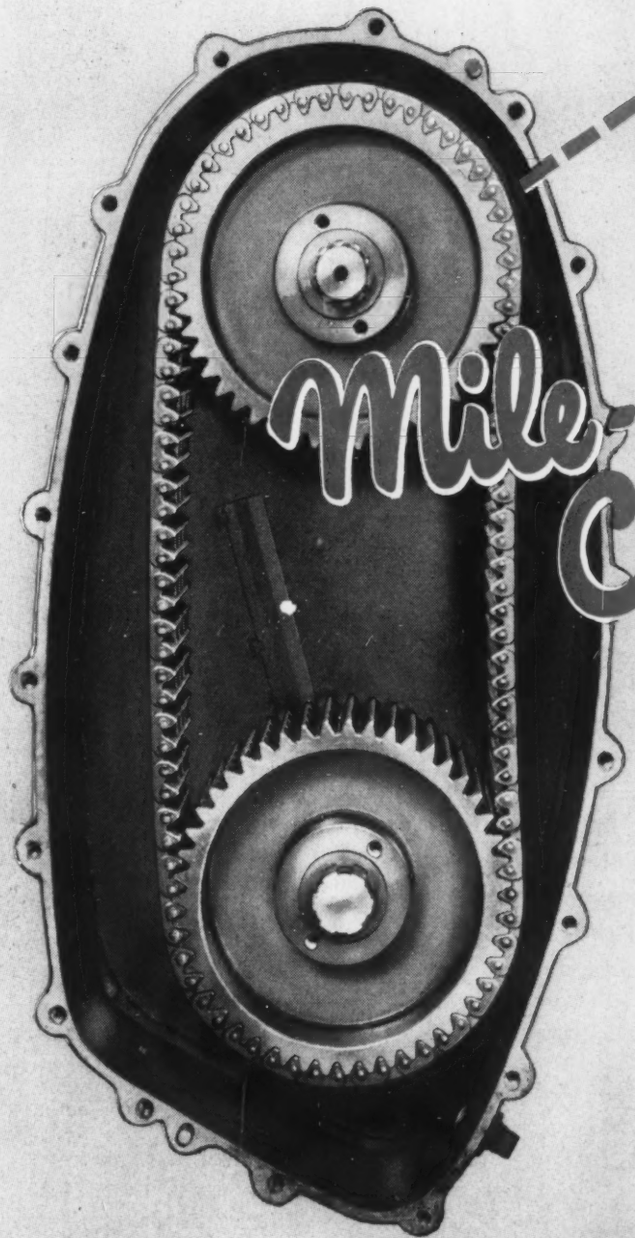
IN EVERY COMMERCIAL FORM

A PRODUCT OF
BORG-WARNER





LINN Coach's removable power unit with Linn-Morse Transfer Case.



Mile-a-Minute Chain!

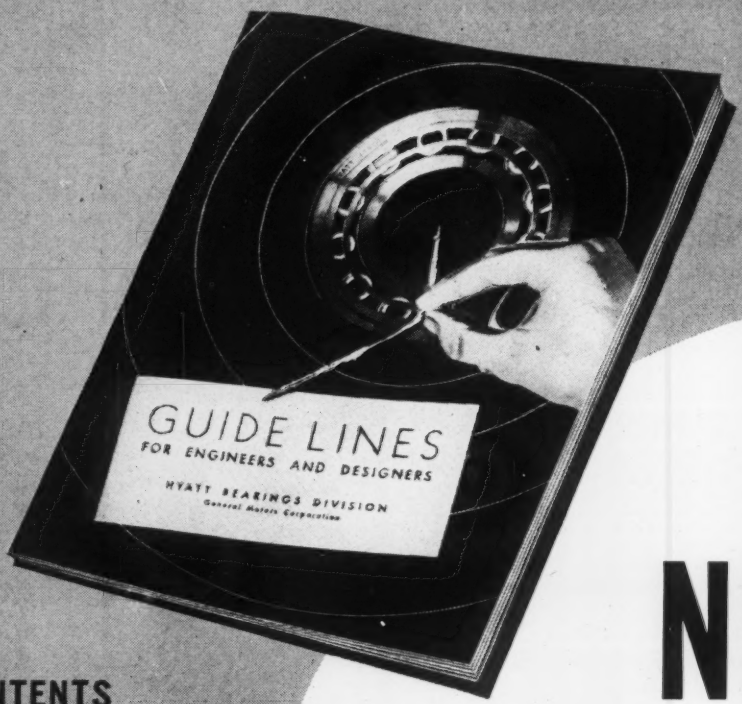
Power goes "AROUND THE BEND" in the Linn Front-Wheel Drive

LINN Coach & Truck Division of Great American Industries combined ingenuity and Morse chain to solve the problem of a U-turn in power flow to its front-wheel drive, originated, designed and developed by A. R. Perkins.

Morse High Speed Silent Chain operates at speeds as high as 6,000 feet per minute! Consult Morse engineers on applications.

MORSE CHAIN COMPANY
Detroit 8, Michigan • Ithaca, New York

MORSE
MECHANICAL POWER TRANSMISSION PRODUCTS



NEW!

HY-ENG.-3

A Handy Reference every designer of products using Roller Bearings will want

This new 35-page Hyatt handbook is just what the name implies—a guide to the proper application of cylindrical roller bearings in machinery and equipment of all types.

With design drawings of successful, tested applications, it illustrates the fundamental needs which must be provided for in the machine design: namely—retainment, shaft location, housing, lubrication, seals and closures.

Written as an accessory to the personalized counsel of the Hyatt Engineering Service, Guide Lines is a "thought starter" for engineers and designers . . . a book you can refer to frequently and profitably.

FOR A FREE COPY write to Sales-Engineering Department, Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey. Due to the fact that this is a limited edition, only requests on company letterheads can be filled.

CONTENTS INCLUDE:

13 methods of retaining the bearing and its component parts in correct operating position.

11 methods of locating shaft and housing . . . by means of shouldered race bearings; by means of auxiliary devices.

13 types of housing design... rigid, self-aligning, solid, split.

10 most commonly used methods of providing for proper bearing lubrication.

15 types of seals and closures for use with roller bearings.

Also: Provision for unequal expansion due to heat—size of shaft and housing fillets—mounting bearings in non-ferrous metal housings—shaft shoulder diameter to insure free access to machine parts.

HYATT ROLLER BEARINGS

Sirvene begins in the mind of an engineer . . . it grows from the need for a special pliable part to complete his mechanism. It is specially compounded from oil resisting elastomers in Chicago Rawhide Laboratories to achieve required physical characteristics, then molded to precise design specifications. The finished Sirvene part meets *exactly* the engineer's demand for flexibility or hardness, resistance to temperature extremes, dryness, wear, age, oil, water, or other solvents. Sirvene parts deliver dependable performance under the most difficult operating conditions. For the solution to your pliable parts problem—consider Sirvene *first*.

Sirvene products include diaphragms, boots, gaskets, oil seals, washers, packings, and other special molded mechanical pliables.

SIRVENE

THE SCIENTIFIC COMPOUNDED ELASTOMER

A Product of the Synthetic Rubber Division

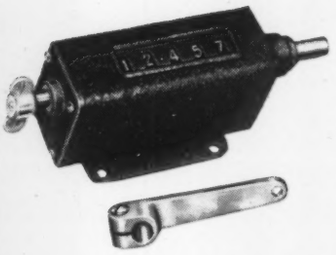
CHICAGO RAWHIDE MANUFACTURING CO.

1305 Elston Avenue

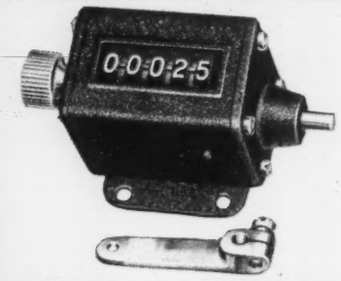
Chicago 22, Illinois

You Can COUNT on Veeder-Root Devices in more ways than you can think of

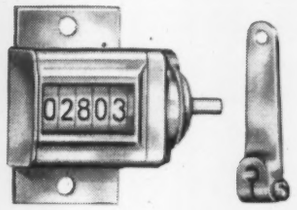
2-3 Pick Counters record the production of textile looms. Can be economically converted from 2 to 3 shift operation right in the mill.



High-Speed Reset Counters, used on coil-winders, etc.

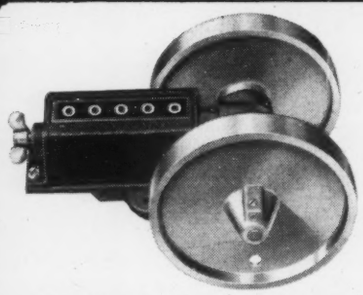


Small Reset Counters, used on office and light production machines.

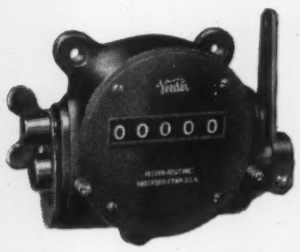


Small Square Case Counters, used on cash registers, office appliances, etc.

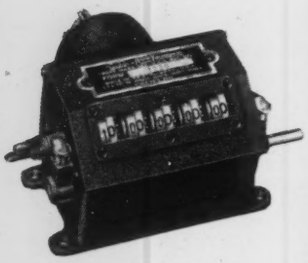
Hand Tally, adds one for each pressure on thumb-lever.



Worm-Driven Counters indicate in yards, feet, meters, other units.

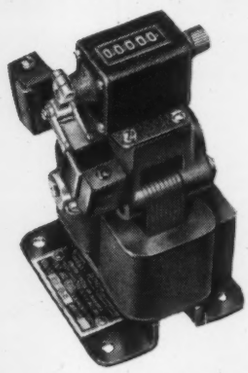


Heavy-Duty Ratchet Counters count strokes on punch presses, etc.



Predetermining Counters stop machine or signal operator at pre-set count. Prevent overruns & shortages.

Medium Size Counters, used on machines of moderate speeds.



Magnetic Counters flash machine-output from factory to office, etc.

"VEEDER-ROOT COUNTS EVERYTHING ON EARTH" . . . motions, pieces, units, distances, light-flashes, gunfire, people, coins, sales, flow of fuel and water . . . and whatever *you* have in mind. Scores of different types of standard Veeder-Root Counting Devices are built into all types of products to add new utility, marketability, *profitability*. And special Veeder-Root Devices are continually being designed to do remarkable things in unheard-of applications. For a quick picture of counting possibilities, write for the new, brief book of "Facts-in-Figures."

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● Even K & E has never devised an instrument that would make it unnecessary to *think*. But we have spent 78 years designing and producing things that make it easier to *act* after thinking . . . drafting instruments and related materials that give the engineering hand and eye almost the same precision as the engineering brain. How well K & E products serve as partners in creating is shown by the reliance placed in them by engineers and draftsmen throughout the world.

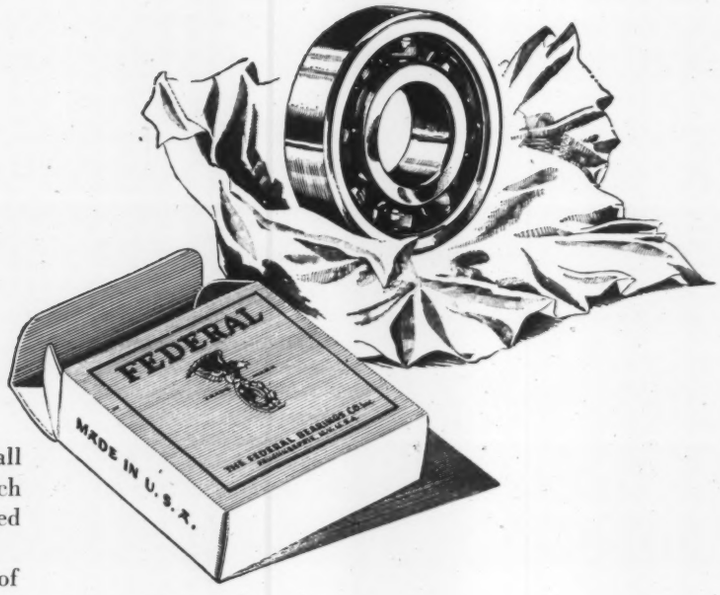
So widely is this equipment used that practically every great American engineering project has been completed with the help of K & E. Could you wish any surer guidance than this in the selection of your own instruments and materials?

To make measurements with the greatest ease and the least chance of error, choose a WYTEFACE* steel tape or tape rule of the type made especially for your work. Their jet black markings against their white background are as easy to read in the brightest glare as in the dimmest light. They are readily kept clean, are rust-resisting and hard to kink. For full information about them write to your nearest K & E Distributor or to Keuffel & Esser Co., Hoboken, N. J.

*Trade Mark

WYTEFACE Steel Tapes and Tape Rules are protected by U. S. Pat. 2,089,209

Higher Speeds are in the package, too



Stepped-up speeds are an ever-present challenge to a ball bearing's precision life. For here unbalanced forces which may be negligible at low speeds are greatly accentuated unless bearing run-out is held to an absolute minimum.

That's why many careful hours go into the grinding of Federal Ball Bearing races, to produce inner and outer races concentric with each other and to prevent run-out... regardless of the r.p.m. Moreover, the bore is cylindrical, not tapered or bell-mouthed, and the sides of the rings are held parallel to each other and the ball track. Proper operating fit is the end result, and the right running clearances are maintained in the housing and on the shaft.

Federal-manufactured balls are "speed-conditioned," too. All are uniformly spherical within .000025", and do not vary in diameter more than .00005" in any bearing. Selective assembly of balls and race rings preclude any Federal Bearing from being too tight or too loose.

Every fourth operator is an inspector at Federal. They see to it that higher speeds are "wrapped" into every Federal Ball Bearing package along with quiet-running, longer life and extra capacity for the heavier loads.

Bear this in mind *wherever tolerances are tight* and specify Federal Ball Bearings...in any range or size.

THE FEDERAL BEARINGS CO., INC. • POUGHKEEPSIE, NEW YORK

Makers of Fine Ball Bearings

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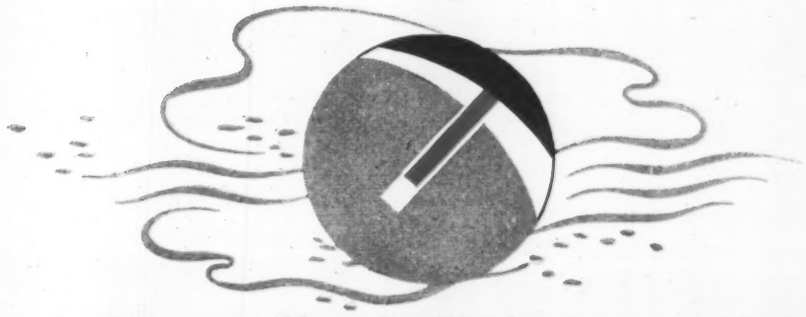

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. . . in the New Explosion-Proof Gast Air Motor

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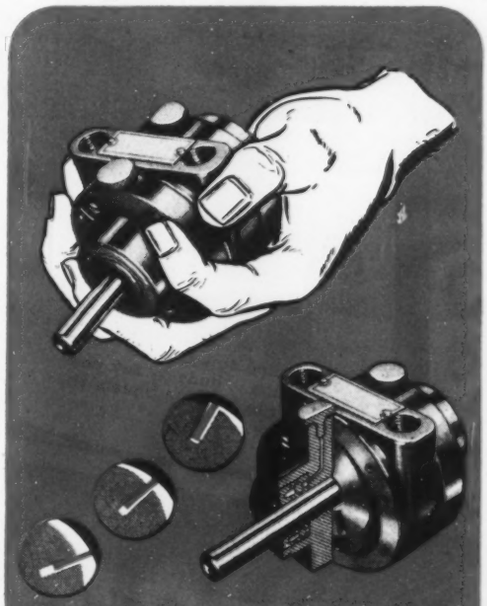

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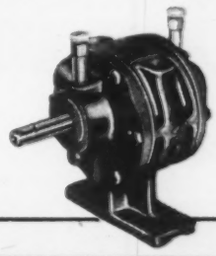

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It not only tells how Gasts are built and all about them, but suggests uses that may not have occurred to you. Write for it; no charge or obligation!

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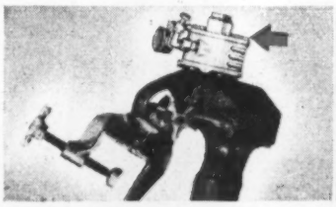
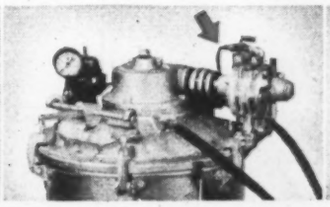
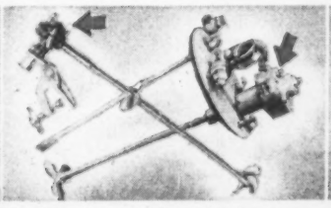


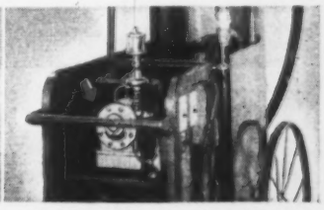
A Gast Air Motor on a Portable Mixer.



Gast Equipment on a Spray Outfit.



Gast Air Motors on Portable Agitators.



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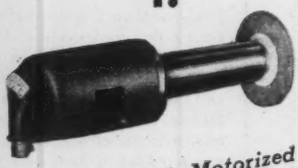

POPE Sealed Motorized 6" x 18" Surface Grinder Spindle with sealed-in 1 HP motor and *sealed lubrication* SKF super-precision, double row, roller bearings. Produces finer finishes. Roughs off surplus metal fast. Write for *Data Sheet No. 12.*

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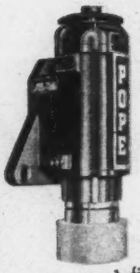

POPE Motorized Spindle for Surface Grinders and Boring Mills with *sealed lubrication* and 3, 5 or 10 HP motor running at 1200, 1800 or 3600 RPM. Produces better final finishes. Increases production. Runs in any position. Write for Data Sheets 16, 17, 18, 19.

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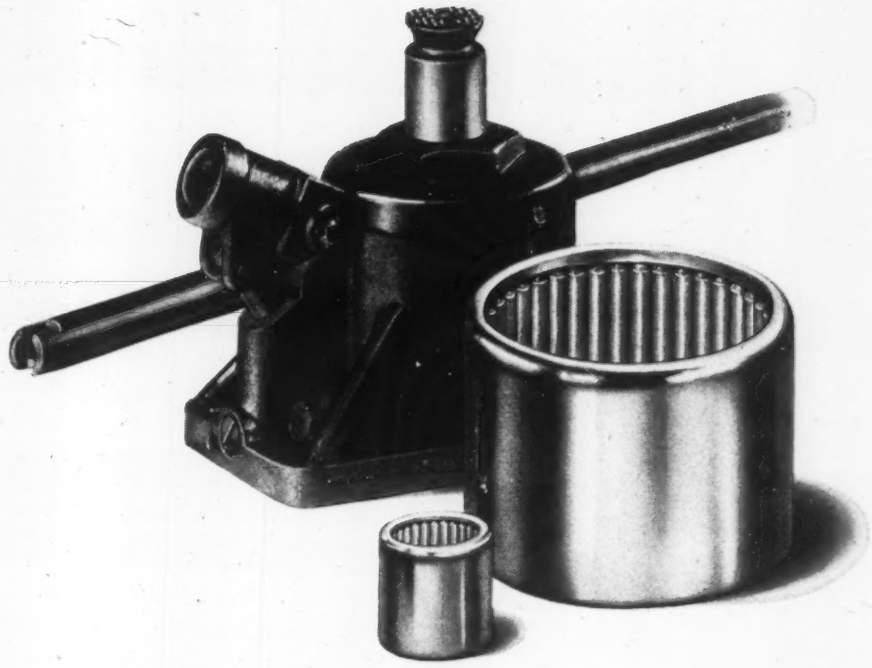

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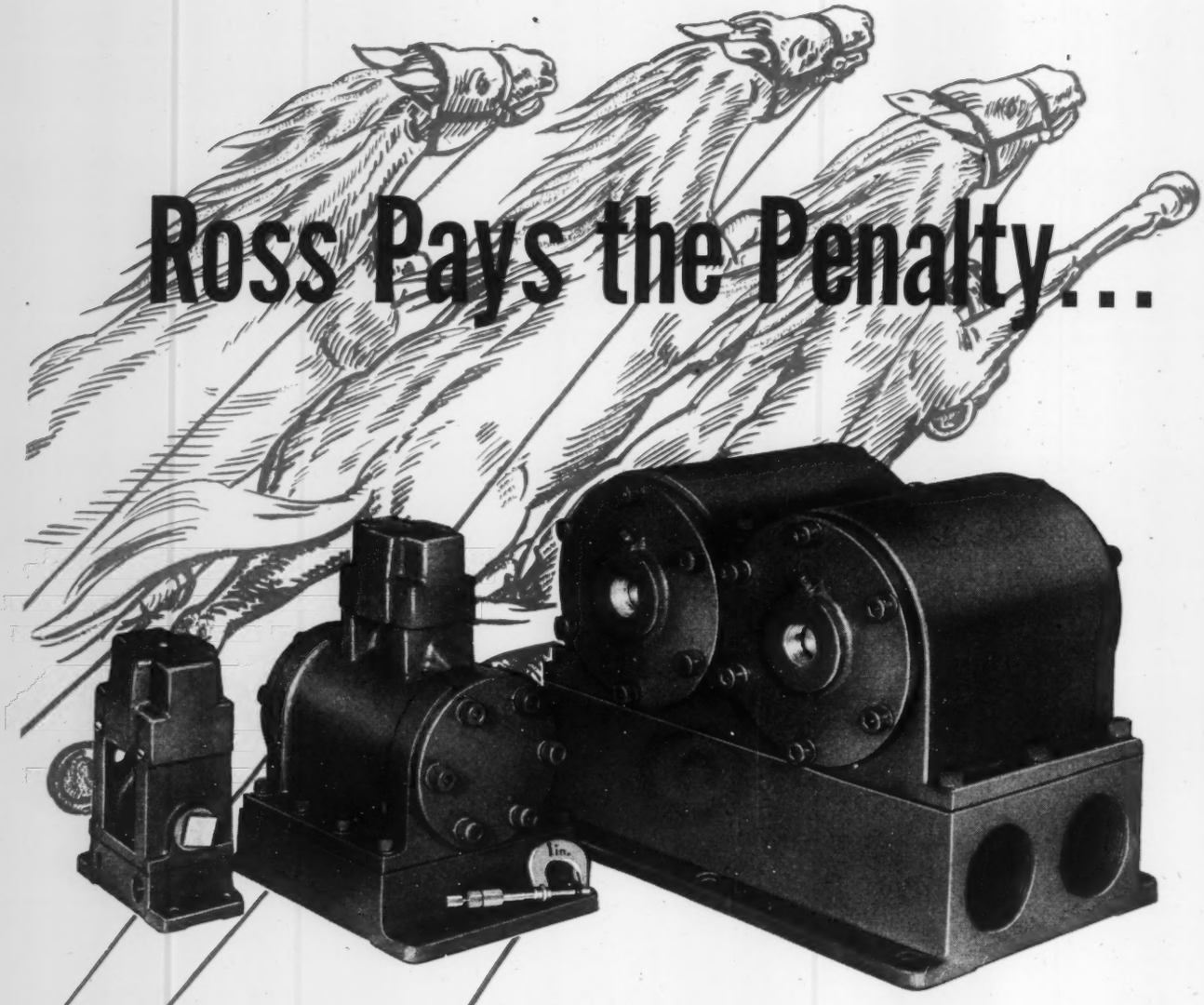

Years of leadership in air power control has piled a burden of responsibility on Ross engineering and production genius. But you'll see no shirking here, for Ross seeks new problems . . new challenges . . . in order to provide new solutions to the complexities of air-controlled operations in industry.

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The scope of the Ross line is symbolized by the three valves shown . . .

#700—¼" to ¾" pipe size, available as 3-way, 4-way, or 4-way, 5-port. Solenoid operated, a general-purpose control.

#707—2" capacity, 3-way, solenoid operated. Introduced by Ross recently, units were incorporated in the design of a continuous steel tube piercing mill, unique in its field. All operations automatic.

#664—3" pipe size, 4-way, 4-port hydraulically operated air valve. Designed and built by Ross for a series of giant die-casting presses. While this installation is hydraulically motivated, the valve may be solenoid operated on either air or hydraulic press application.

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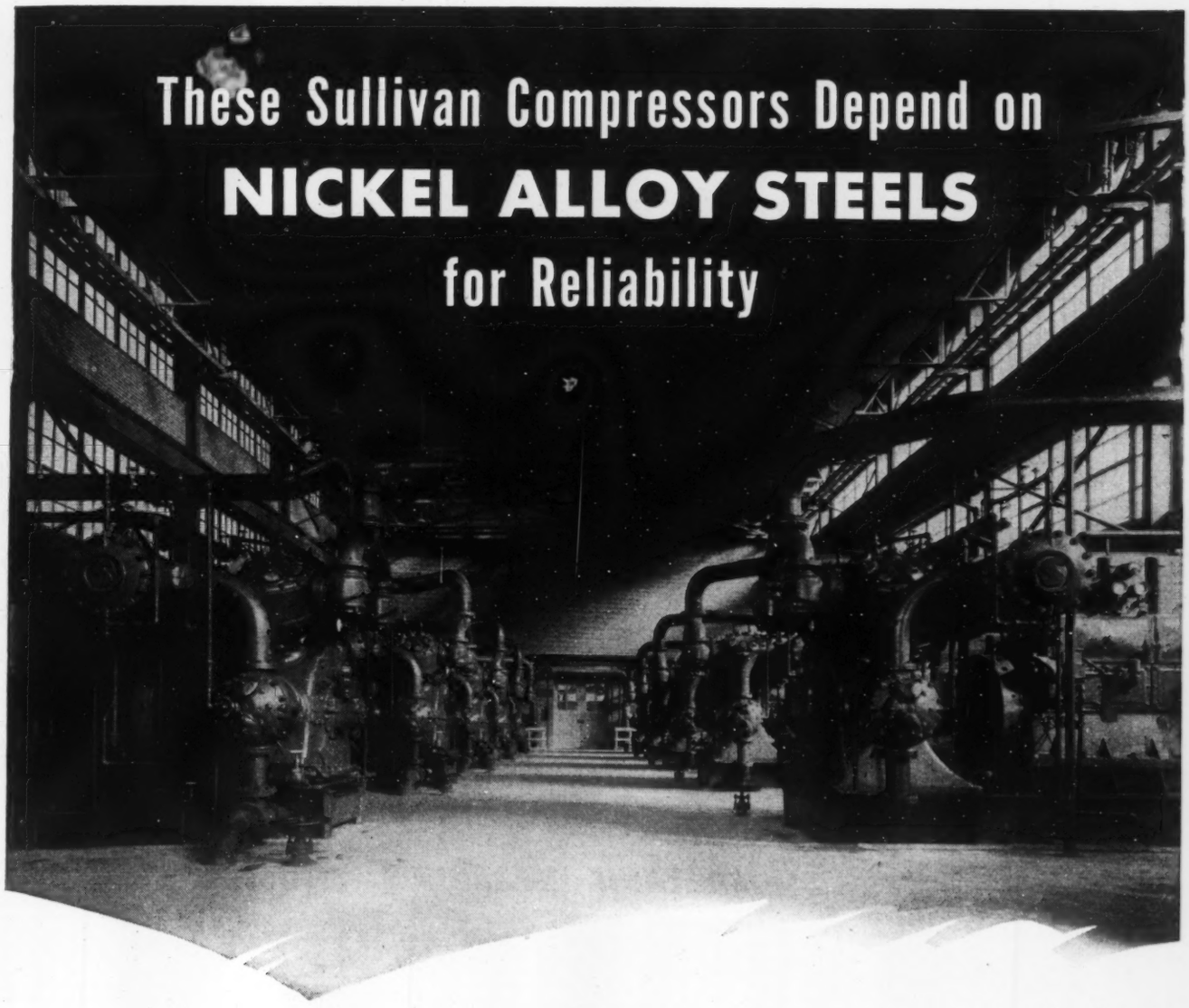

These compressors, built by the Sullivan Division of Joy Manufacturing Company, are a good example of the way Nickel alloy steels help make equipment longer-lasting and more dependable.

Crankshafts in these units are of large diameter, and accordingly, a Nickel-chromium-molybdenum steel, Type 4340, is used to secure good depth hardening. This steel makes possible heat treated forgings that provide ample strength, good ductility and ready machinability.

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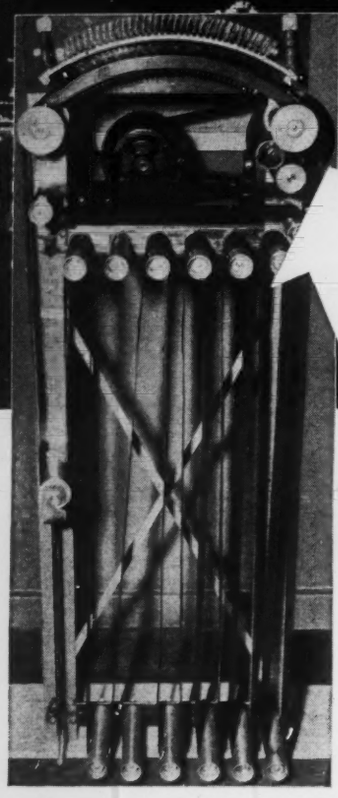

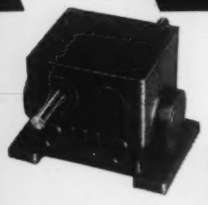

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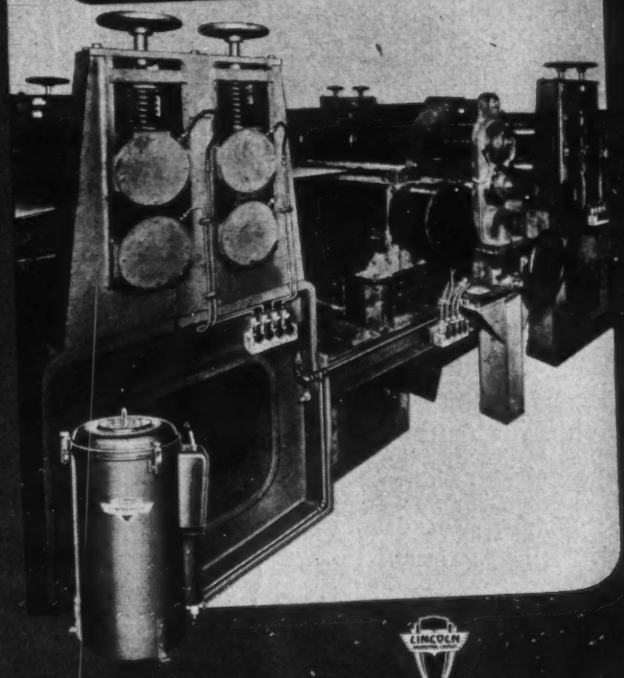

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Welded Steel Cuts Cost of Base 45%

By W. E. Benninghoff, General Manager
TOCCO Division
The Ohio Crankshaft Company, Cleveland, Ohio

BY thinking in terms of welded design for the fabrication of parts and assemblies of TOCCO Induction Heating Equipment, we have been able to benefit in two important ways.

1. Day after day, we use welded design in the development of work-handling fixtures and accessories for standard TOCCO machines and in the designing of special TOCCO machines. Each must be built to match a specific application. Welding permits us to use greater ingenuity and freedom in the design of this equipment and to manufacture quicker, at lower cost.

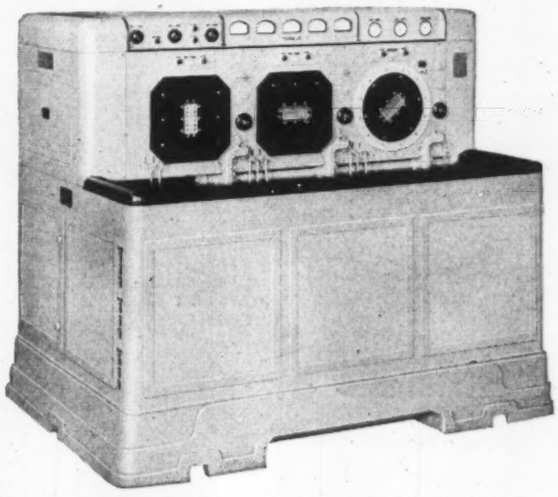

Fig. 1. Completed TOCCO Induction Heating Machine with former base.

2. In the manufacture of our standard TOCCO machines of all sizes and types, we use welded design for many parts to provide maximum rigidity and strength, lighter weight and lower cost. It also enables us to continually improve these parts because we are not restricted by patterns. The cabinet frame of the 150 KW TOCCO unit shown in Fig. 1 is an example of the larger welded steel parts which we have used for some time.

Recently we have also changed the base of the machine shown in Fig. 1 from cast iron to welded steel. The cast iron base weighed 3175 lbs. compared to 1180 lbs. for the welded steel base shown in Fig. 2. It was necessary to machine the top of the cast base to secure level mounting for the motor generator set. The welded base is sufficiently level as fabricated and requires no machining, thus providing further saving.

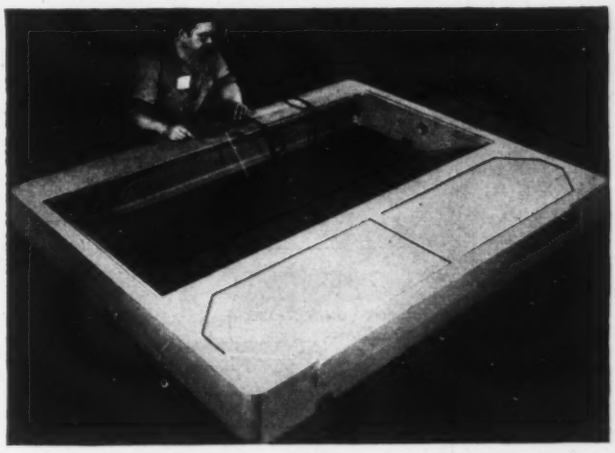

Fig. 2. The new welded steel base for 150 KW machine shown in Fig. 1.

The total net cost saving with the welded steel base is 45%.

The base of this TOCCO machine supports a 150 KW high-frequency motor-generator, transformers, electrical controls and other equipment, housed in a steel cabinet. The total weight of the machine, including the base, is about 12,000 lbs. In service, it must be permanently level, rigid and have good vibration-dampening qualities.

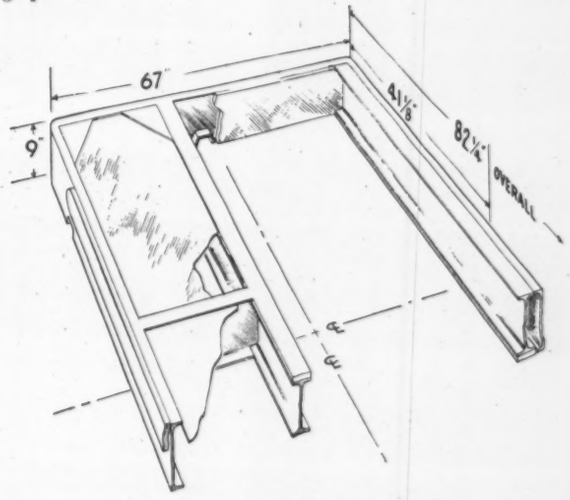

Fig. 3. Schematic drawing of fabricated base.

The construction of the welded steel base is shown in Fig. 3. Made of standard mill shapes and plate, it requires a minimum amount of welding, resulting in close control of tolerances and minimum cost. It is proving highly satisfactory in performance in every respect.

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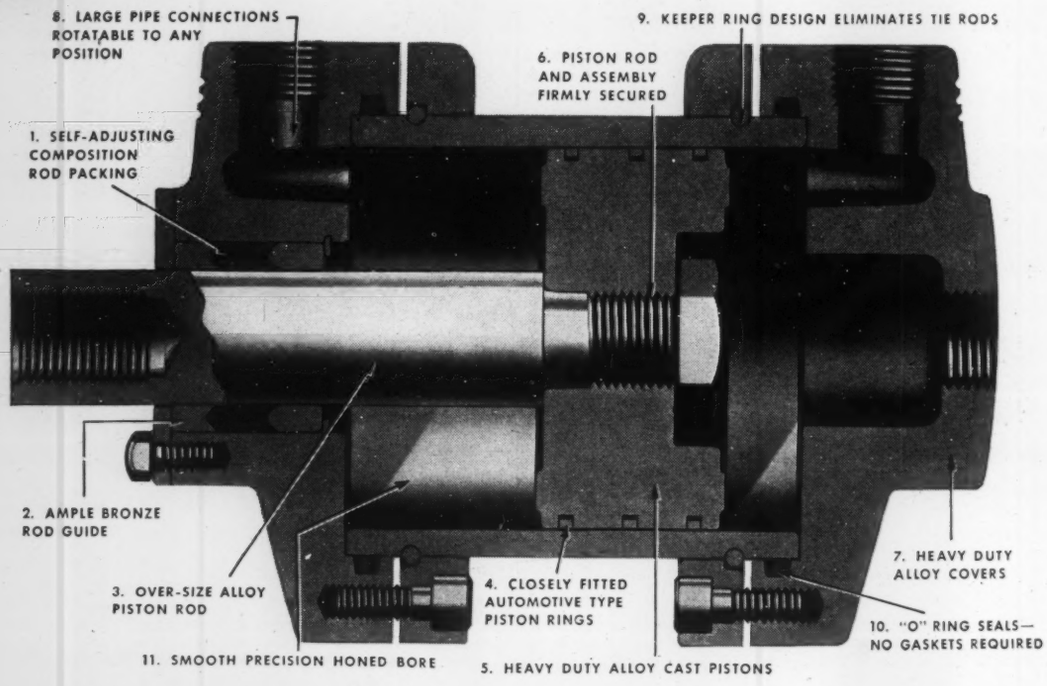

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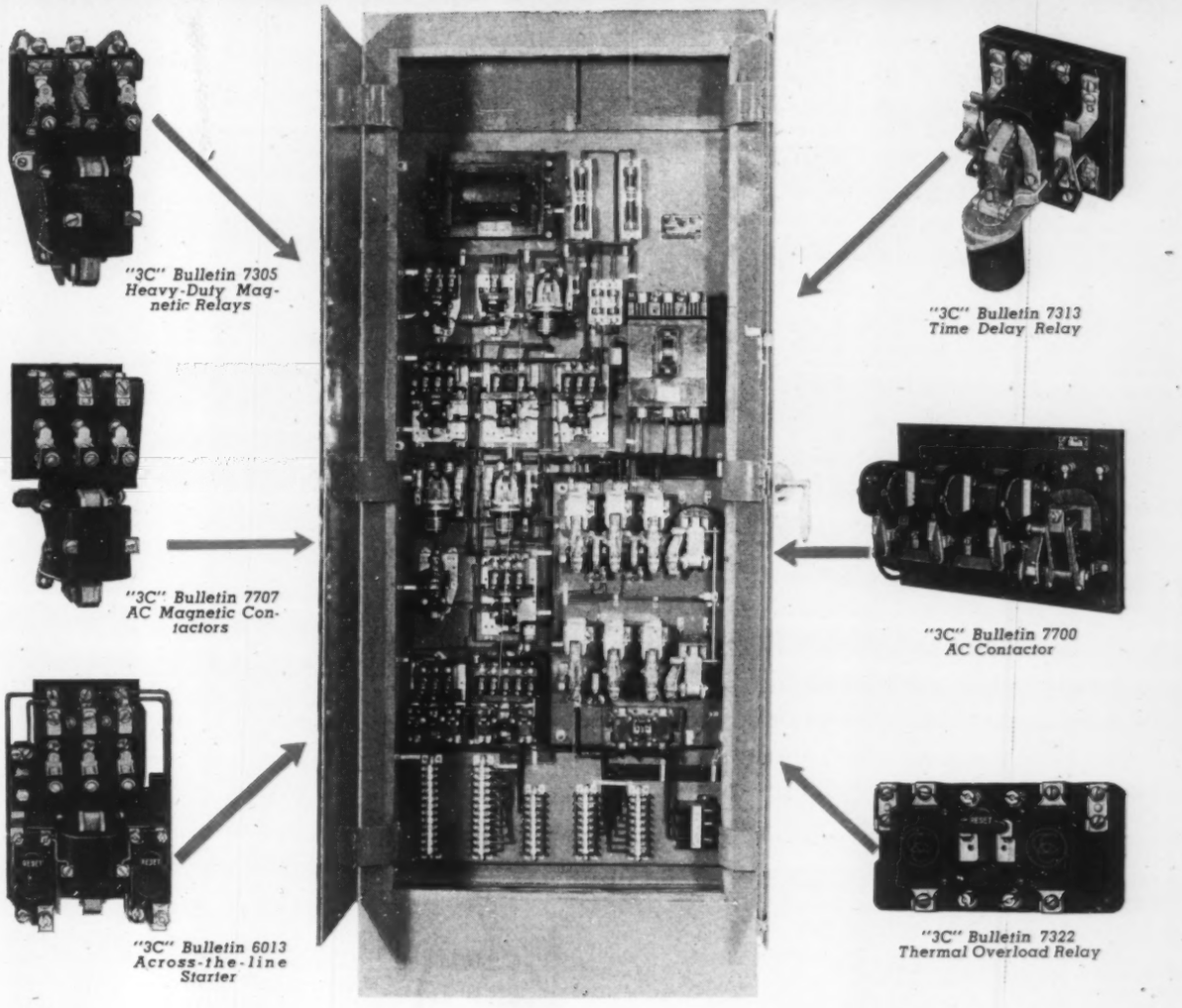

"3C" Bulletin 7305 Heavy-Duty Magnetic Relays

"3C" Bulletin 7313 Time Delay Relay

"3C" Bulletin 7707 AC Magnetic Contactors

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"3C" Bulletin 6013 Across-the-line Starter

"3C" Bulletin 7322 Thermal Overload Relay

● This "3C" Control Panel provides completely automatic operation of a machine which finish-turns crankshaft pins and walls.

This machine is powered by a 30 H. P. main drive motor, a 7½ H. P. hydraulic pump motor and a ¾ H. P. coolant pump motor.

Standard "3C" electrical control apparatus makes up this panel and the crankshafts are machined in 35 seconds each.

The "3C" standard sturdy relays, contactors, and motor starter were engineered into a design which permits this rapid operation. This panel is typical of many electrical control problems solved successfully by "3C" engineers.

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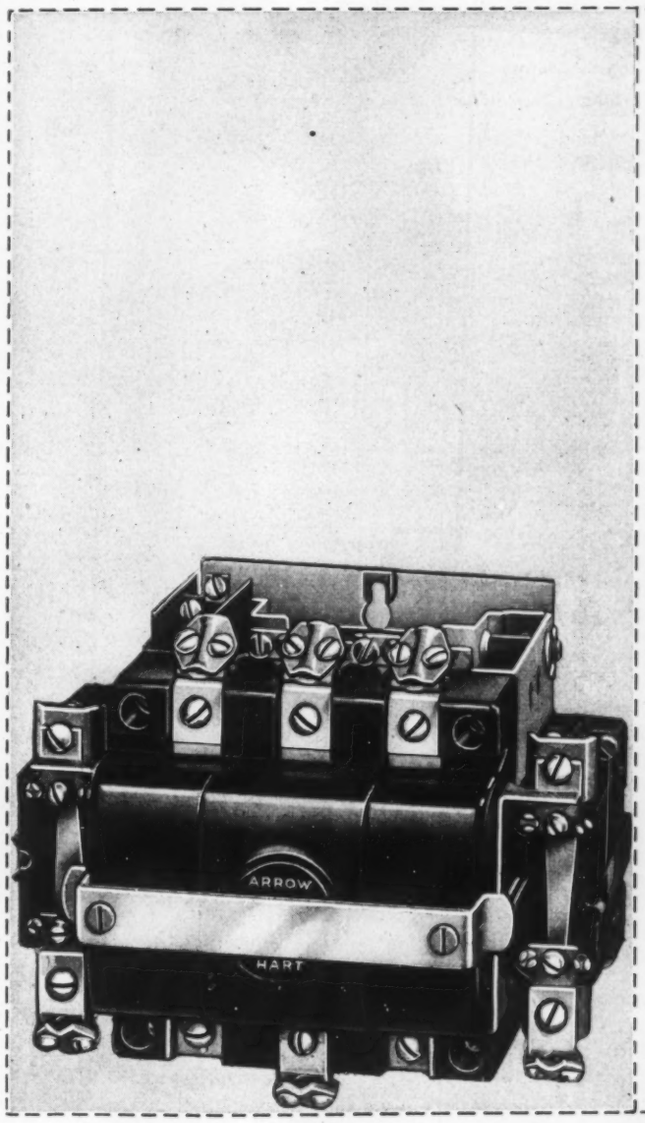
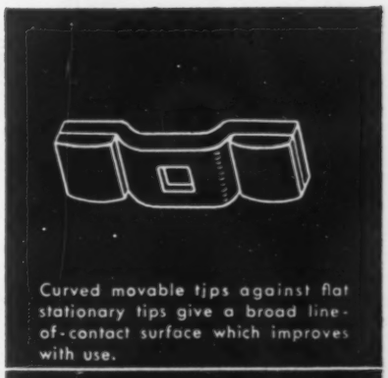
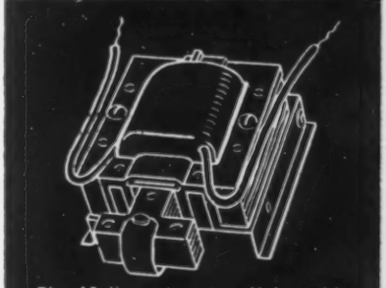


SIZE 2; Type RA

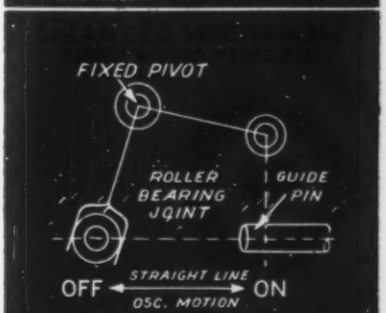
Half the size of the conventional Starter



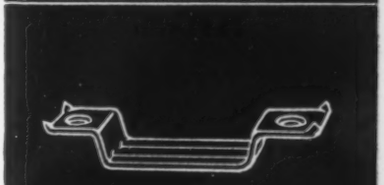
Curved movable tips against flat stationary tips give a broad line-of-contact surface which improves with use.



The 15-lb. magnet pull is multiplied to 25-lbs. at the contacts. Requires but 8.5 Watts closed, 75 Watts inrush.



Straight-line horizontal action provides for full use of magnet power without lifting extra weight.



Interchangeable heaters give a range of 7.4 Amps. minimum, 8.3 maximum to 46.1 Amps. minimum, 50.0 maximum.

ARROW AH HART

TYPE "RA" Starter embodies a basic new operating principle permitting of *compact design* never before approached. The straight-line horizontal action is engineered to produce a switch just *half the height* of the conventional Starter. Size —New No. 2 — only 5" high, 6½" wide. This space-saver provides a uniquely dependable control for streamlined machine designs.

THE ARROW-HART & HEGEMAN ELECTRIC COMPANY, HARTFORD, CONN., U.S.A.

A real performance and a real product - - EverLOCKS!

Mauri Rose

THE 1947 WINNERS USED

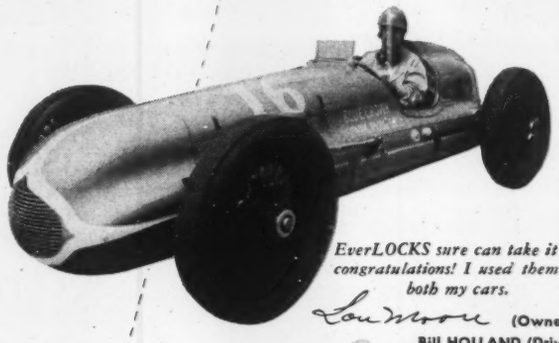
EverLOCK WASHERS

For the eighth consecutive time the winners of the Indianapolis 500-mile Sweepstake equipped their cars with EverLOCK WASHERS

Here is ample proof that when superior performance is a "must" the choice invariably falls on EverLOCK washers—for EverLOCK washers were used not only on the winning car at the Indianapolis Sweepstake, but also on the cars taking second and third place.

And it's the eighth consecutive time EverLOCK washers have ridden to victory in this grueling race. Top auto racers know that EverLOCK'S patented combination of wide chisel edges and balanced spring tension. is unsurpassed for guarding assemblies.

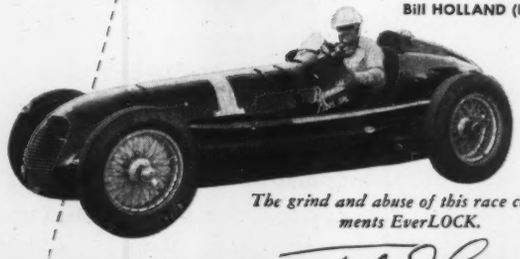
You, too, can enjoy this "double indemnity" against loosened bolts, nuts and screws by using EverLOCK washers.



EverLOCKS sure can take it - - congratulations! I used them in both my cars.

Lou Moore (Owner)

Bill HOLLAND (Driver)



The grind and abuse of this race compliments EverLOCK.

Ted Horn

THOMPSON-BREMER & CO., 1636 W. HUBBARD ST., CHICAGO 22, ILL.

to designers looking for:

a compact economical unit for positioning blades etc. . . — ROAD GRADERS, ETC.

Variable speed, accurate fast control and consistently accurate duplication of movements . . . — PACKAGING MACHINERY, ETC.

Fast, snappy action in moving heavy loads quickly and accurately to required heights . . . — MATERIALS HANDLING EQUIP., ETC.

Effective speed and feed controls and consistently accurate clamping pressures. — MACHINE TOOLS, ETC.

You'll find your needs in the proper combination of these SUNDSTRAND STANDARD HYDRAULIC ELEMENTS

Yes, hydraulic circuits designed with the proper combination of these standard Sundstrand elements offers the best solution to your hydraulic equipment design problems. Proper combinations and circuit design are arrived at through design conferences between you and our hydraulic application engineers.

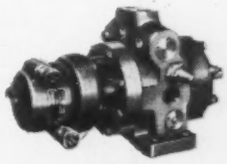
When designing new equipment or redesigning present models, call in a Sundstrand hydraulic application engineer. He will suggest the best combination of these hydraulic elements to meet your design requirements.

There is no obligation for this service.

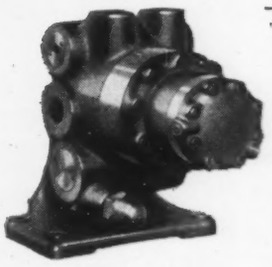
FREE ADDITIONAL DATA

is included in this set of bulletins. Write for your copies today. Ask for Bulletin M-19.

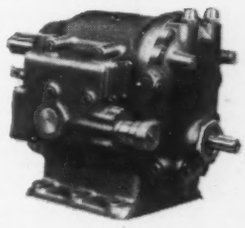
FLUID MOTORS



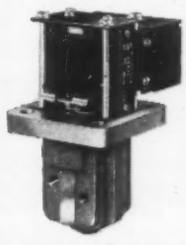
PUMPS



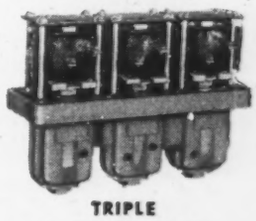
CLAMPING PUMPS



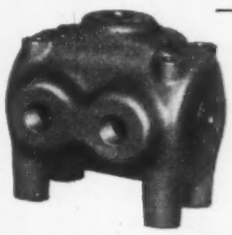
TRANSMISSIONS



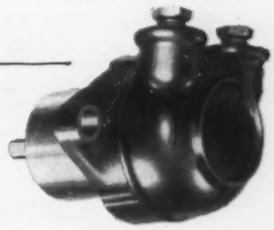
SINGLE SOLENOID VALVES



TRIPLE SOLENOID VALVES



FOUR-WAY VALVES



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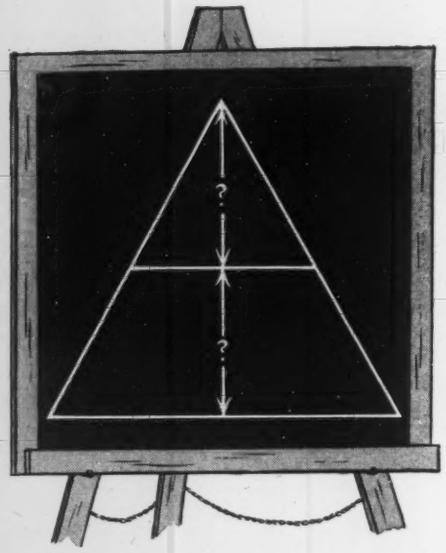
FUEL UNITS • HYDRAULIC PUMPS • TRANSMISSIONS • FLUID MOTORS • VALVES and CONTROLS

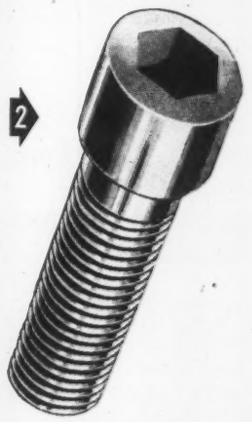


Are you Sure

A SIZE IS WHAT IT SEEMS?

1. Which section is taller, top or bottom?

What size is this Socket Screw? 2



ANSWERS:
1. Top section is taller.
2. No question if it's Size-Marked!

● If you get the right answers to these questions, you're one of a select group. For "eye-gauging" fools many a shopman . . . even some of the experts. In a test that required judging the size and pitch of an ordinary socket screw, many failed. On the job, that means they must take *time out* to *find out.*

But there's no question with a P-K Socket Head Cap Screw. The SIZE-MARK clearly incised on the head, shows the size and pitch at a glance. No need to waste time gauging . . . or chance errors by guessing. This P-K "exclusive" will simplify and speed up identification . . . and assembly work. Ask the men in your shop.

Assembly line operators report valuable time saved because sizes are always issued correctly . . . *tool crib bosses* say sorting is made easier, speeded up . . . *new help* agree sizes can be learned faster . . . all because of the P-K Size-Mark. And *Sales Managers* recognize the Size-Mark as an added sales feature . . . a definite aid to customers' service men in reassembly.

Plus—GEAR GRIP*

Makes fast fingers, sure fingers . . . makes them slip-proof even when oily. Only P-K offers both Size-Mark and Gear Grip in Socket Head Cap Screws.

SEND FOR FREE SAMPLES NOW. See P-K's years-ahead advantages in contrast with ordinary Socket Screws. Compare and judge for yourself. Parker-Kalon Corp., 200 Varick Street, New York 14, N. Y.

There isn't any question...

IF IT'S P-K... IT'S SIZE-MARKED

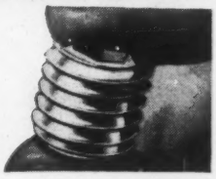
P-K SOCKET SCREWS ARE
AVAILABLE FOR PROMPT DELIVERIES.
SEND FOR STOCK LIST NOW.

*U. S. Pat. No. 126,409

SOLD ONLY THROUGH ACCREDITED DISTRIBUTORS

PARKER-KALON *Cold-forged* **SOCKET SCREWS**

Another P-K First — *GROUND THREAD* Socket Set Screws



Smooth, mirror-bright, clean finished threads—centerless ground on hardened blanks. Faultless contour and lead, dependable Class 3 Fit. Free from imperfections common to ordinary cut thread set screws . . . a "shining example" of good workmanship. Get samples now . . . see and feel the difference!

MACHINE DESIGN

Announces . . .

THE 1947 DIRECTORY of MATERIALS

to be published as a part of the October issue

This fourteenth Directory of Materials is being completely revised and brought up to date by the MACHINE DESIGN editors to give you authoritative data on engineering materials. For your convenience, the Directory will be published in three sections which will contain:

1. **Detailed descriptions of properties, characteristics and typical applications of FERROUS AND NONFERROUS METALS and ALLOYS, PLASTICS and other NONMETALLICS—all conveniently arranged, alphabetically by tradenames.**

2. **An INDEX of MATERIALS arranged alphabetically by principal constituents which will enable you to select materials according to their chief properties, compare properties of similar materials and find tradenames.**

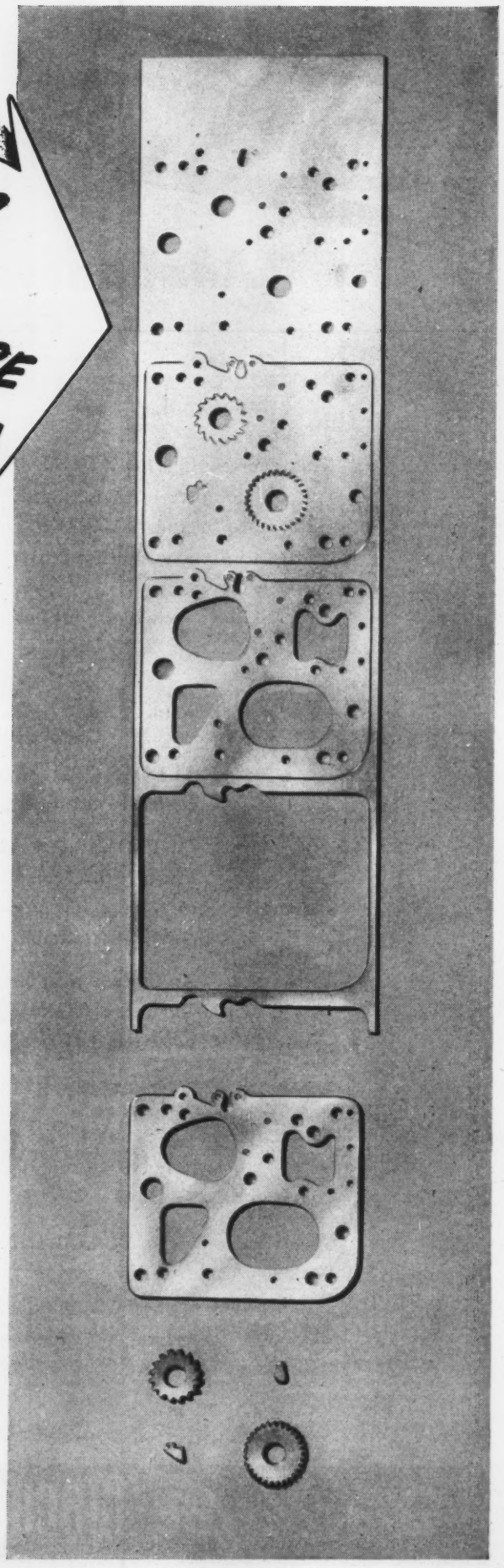
3. **An alphabetical listing of PRODUCERS of METALS, PLASTICS and other NONMETALLICS together with an explanation of the materials produced and their trade names.**

All of these data are to be arranged and compiled for your convenience so that whenever you need information on engineering materials it will be literally "at your pencil point".

The October issue of MACHINE DESIGN, containing this Directory of Materials will be a time-saving reference that you will want to keep on hand at all times. A limited number of extra copies of the Directory will be available from the Readers' Service Manager of MACHINE DESIGN, Penton Building, Cleveland 13, Ohio. They will be priced at $1.00 per copy.

Watch for MACHINE DESIGN October Issue

CLEVER PLANNING REDUCES SCRAP— SPEEDS MANUFACTURE



THIS photograph shows progressive steps in the manufacture of a clock frame, and is an excellent example of careful planning to reduce the amount of scrap and lessen the number of operations. Note that in only a few strokes of the machine not only is a plate punched for the frame, but also a gear, a ratchet wheel, and two other small parts are produced. The work is done on a dieing machine, which operates to the very close limits that are essential in a clock. An additional item of economy is the fact that most of the other parts are made from exactly the same kind and gauge of metal, greatly simplifying purchasing, stockroom management, and production ordering.

Planning such as this is more important than ever today, when metal is scarce, and it is essential to conserve it, as well as lessen costs and speed production.

The metal used is Revere Leaded Brass, supplied to exceptionally close limits as to composition, gauge, temper, flatness, and straightness. Revere takes pride in its ability to meet these strict requirements, and will be glad to collaborate with any manufacturer in working out the application of its metals to modern, simple, accurate, metal-and-money-saving plans and processes.

REVERE

COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

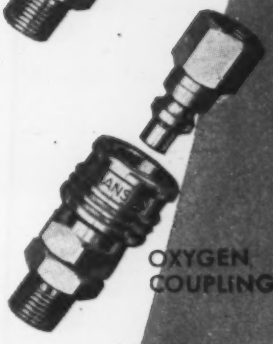
230 Park Avenue, New York 17, New York

Mills: Baltimore, Md.; Chicago, Ill.; Detroit, Mich.; New Bedford, Mass.; Rome, N. Y.—Sales Offices in Principal Cities, Distributors Everywhere.

Progressive steps in the accurate, economical manufacture of clock parts by the William L. Gilbert Clock Co., Winsted, Connecticut.

HANSEN *Couplings*
Are Used On a VARIETY of JOBS

ACETYLENE COUPLING



OXYGEN COUPLING

AIR, OIL—GREASE COUPLING

EACH DAY a new use is found for Hansen couplings, proving their adaptability, versatility and right design. Hansen couplings have made their mark in many fields and their long list of accomplishments is growing longer each day.

There is a specific Hansen coupling made for air, oil, grease, oxygen, and acetylene, and they come in a wide range of standard sizes.

Hansen couplings are simple and easy to operate — merely push plug into socket, coupling is connected and locked — slide sleeve back with thumb, coupling is unlocked and disconnected. Hansen couplings are rugged, with all moving parts fully protected, consequently they will stand up under rough usage. Complete swivel action prevents kinking of hose. They can be readily incorporated in new or existing equipment.

Our representatives will be glad to discuss with your engineers the possibilities and many advantages of Hansen couplings. Send for illustrated catalog.

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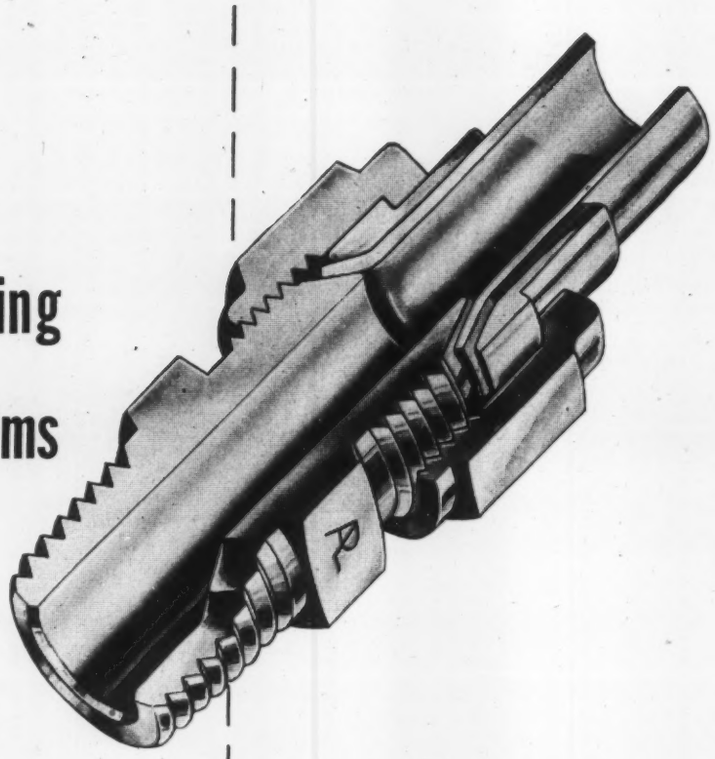
THE HANSEN MANUFACTURING CO.

1786 EAST 27th STREET • CLEVELAND 14, OHIO

This Parker Tube Fitting makes Free Flow systems possible



It takes *tubing* to achieve Free Flow. Tubing can be bent . . . can be connected without creating pockets that cause turbulence. Fewer fittings are required—resulting in fewer chances of leaks.

With PARKER Tube Fittings there's no threading on the tubing. You can use light or heavy tubing. Connections are pressure-tight—protected against leakage, vibration and shock—the result of **precision** manufacture.

With no threading on the job—installation and removal are quick and easy.

For simplified, Free Flow systems, use tubing with PARKER Fittings and Valves. And remember, *every* PARKER Fitting is a *coupling.*

Let PARKER work with you on your systems to carry liquids or gases, under high or low pressure.

THE PARKER APPLIANCE COMPANY
17325 Euclid Avenue • Cleveland 12, Ohio
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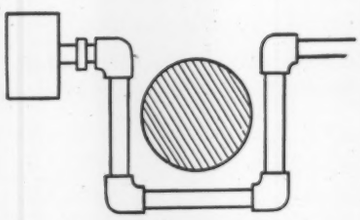
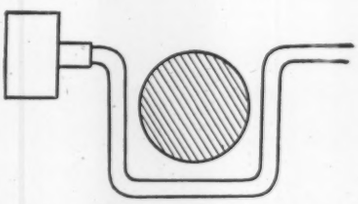
Parker
TUBE FITTINGS • VALVES

FREE FLOW— a comparison



OLD METHOD—Each connection threaded—requires numerous fittings—system not flexible or easy to install and service. Connections not smooth inside—pockets obstruct flow.



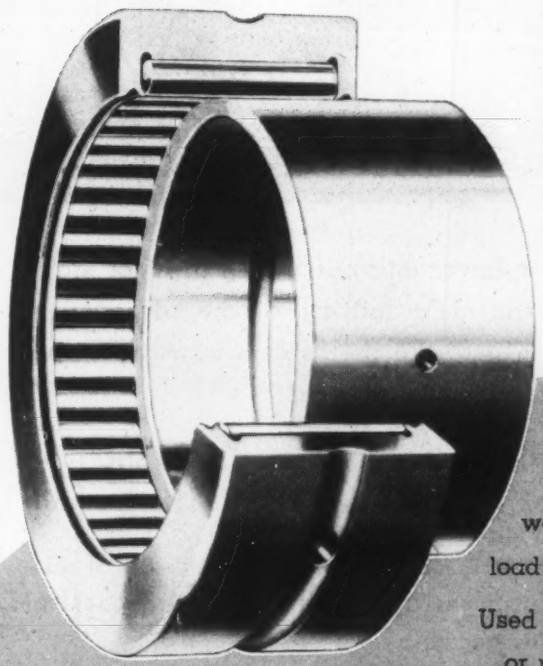
MODERN METHOD—Bendable tubing needs fewer fittings—no "threading on the job"—system light and compact—easy to install or service—no internal pockets or obstructions to free flow.

Write for interesting booklet "Fluid Power".

McGILL PRECISION BEARINGS

provide smooth action and dependability in

OILGEAR FLUID POWER PUMPS AND MOTORS



The "SOLIDEND" *MULTIROL* BEARINGS used in OILGEAR FLUID POWER PUMPS and motors are working proof of McGILL balanced design . . . high load capacity . . . and precision dependability.

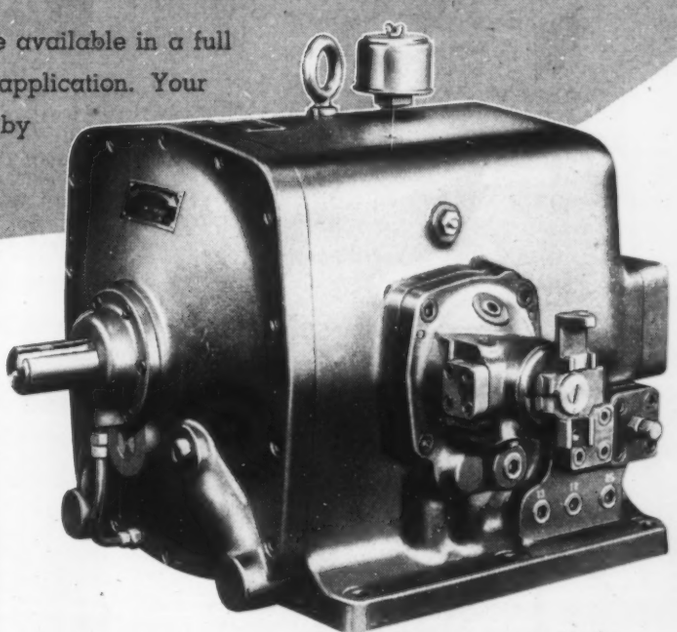
Used to convert rotary motion into stepless variable linear or rotary motion for accurate control of machine function.

OILGEAR PUMPS depend on McGILL precision for smoother, quieter and longer operation.

The ease with which OILGEAR PUMPS operate machine tools, presses, and processing machines is due in part to the high load capacity of McGILL "SOLIDEND" design . . . with its greater effective roller length and solid outer race and roller-retaining end shoulders.

The longer life of "SOLIDEND" *MULTIROL* BEARINGS, due to their rigid construction and adequate lubrication facilities lends to the OILGEAR PUMP a high degree of stamina . . . a minimum of maintenance.

"SOLIDEND" *MULTIROL* BEARINGS are available in a full range of standard sizes to suit any application. Your special problems are welcomed by McGILL engineers.

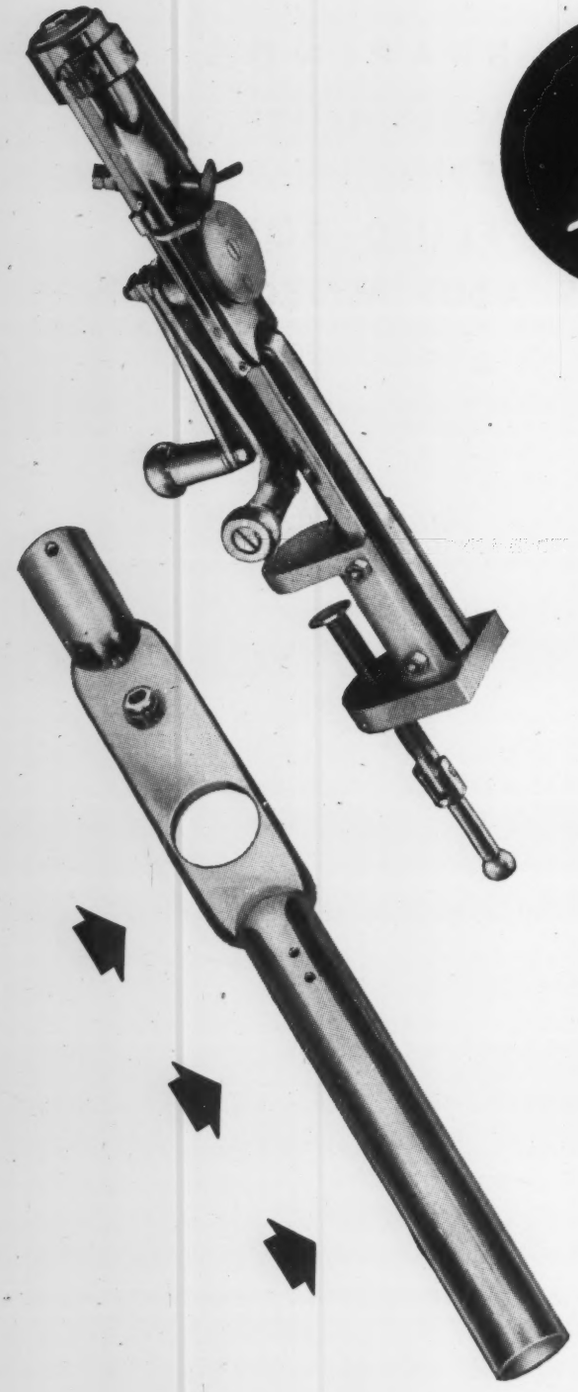


McGILL precision bearings

For complete information write today for bulletin SM-42: McGill Mfg. Company Inc., 200 N. Lafayette St., Valparaiso, Ind.

McGill Selected for

• LONG LIFE • SMOOTH ACTION • DEPENDABILITY.



How These UNIFORM TUBE WALLS

Lower Your Cost of Using Stainless...

For lower unit costs, plus product improvement, make full use of the advantages you can get with the *uniform walls* of Carpenter Stainless Tubing.

- **FULL CORROSION & HEAT RESISTANCE**—no off-gauge or "thin" areas in the tube wall.
- **LOW COST FABRICATION**—because of uniform ductility and consistent physical properties.

In addition to mechanical tests, Carpenter Stainless Tubing is 100% hydrostatically tested before shipment. If you would like samples to test against your own particular requirements, drop us a line outlining your problem.

SELECTION, FABRICATION & USE

Use the new Carpenter Stainless Tubing Data Book as your starting place to reduce the cost of using tubing. Contains over 90 pages of technical data and useful information to help you get the most from Stainless Tubing. Available to Engineering and Management executives. Please write on your company letterhead.

THE CARPENTER STEEL COMPANY

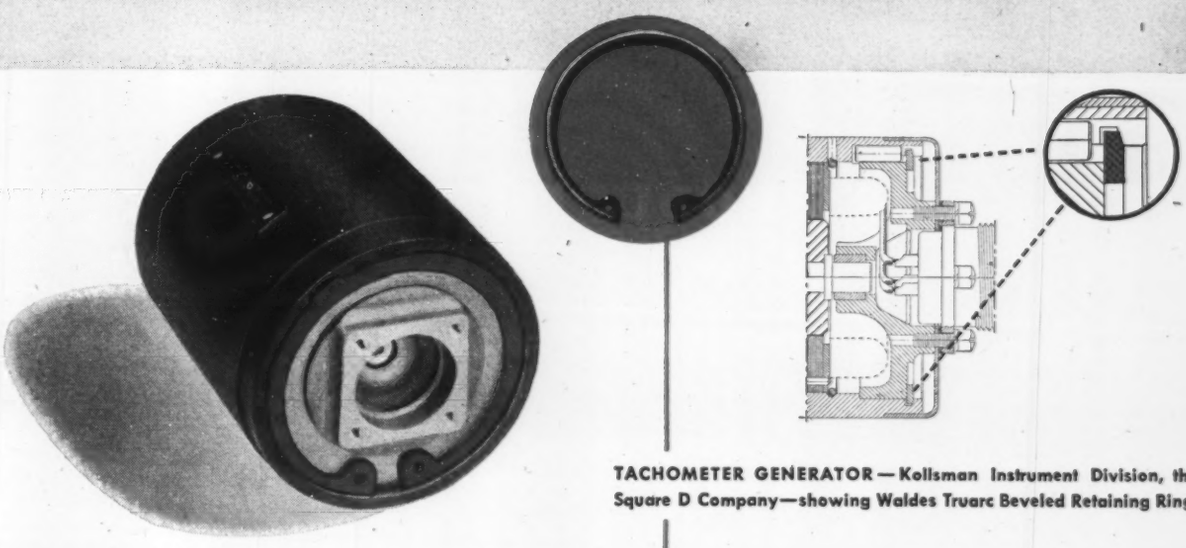
Alloy Tube Division • **115 Springfield Road, Union, N. J.**

Carpenter

STAINLESS TUBING

"MORE THAN CORROSION RESISTANCE"

Truarc Beveled Ring takes up end-play, eliminates shims, saves 20 minutes' assembly time



TACHOMETER GENERATOR—Kollsman Instrument Division, the Square D Company—showing Waldes Truarc Beveled Retaining Ring.

When installed in a groove with a corresponding bevel, the tapered edge of the Beveled ring acts like a wedge and rigidly bridges end-play. End-play can also be taken up resiliently by another type Truarc ring—the Bowed.

Wherever you use machined shoulders, nuts, bolts, snap rings, cotter pins—there's a Truarc ring that does a better job of holding parts together. All Truarc rings are precision engineered, easy to assemble and dis-assemble, always circular to give a never-failing grip. They can be used over and over again.

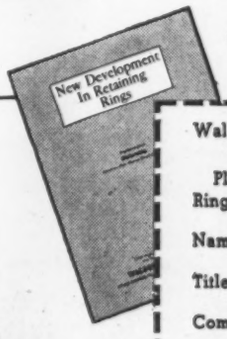
See what can be done for your product: send a drawing to Waldes Truarc Technical Service Engineers for individual attention without obligation.

One Waldes Truarc Beveled Retaining Ring gives Five big advantages:

- Secures the cover with its connecting parts in the housing against strong pressure, heavy vibration
- Absorbs accumulated tolerances up to .010 (ring diameter is 1.9375)
- Eliminates shims, saves material and weight
- Saves 20 minutes' assembly time
- Simplifies field maintenance by facilitating quick dis-assembly, re-assembly

WALDES
TRUARC
Reg. U. S. Pat. Off.
RETAINING RINGS

WALDES KOHINOOR, INC., LONG ISLAND CITY 1, NEW YORK
Canadian Distrib.: Controlite Engineering & Sales Ltd., 20 Bloor Street W., Toronto 5



*Mail this coupon today for your copy of "New Development in Retaining Rings"

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Please send booklet, "New Development In Retaining Rings" to:

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WALDES TRUARC RETAINING RINGS ARE PROTECTED BY U. S. PATS. 2,302,949; 2,026,454; 2,416,852 AND OTHER PATS. PEND.

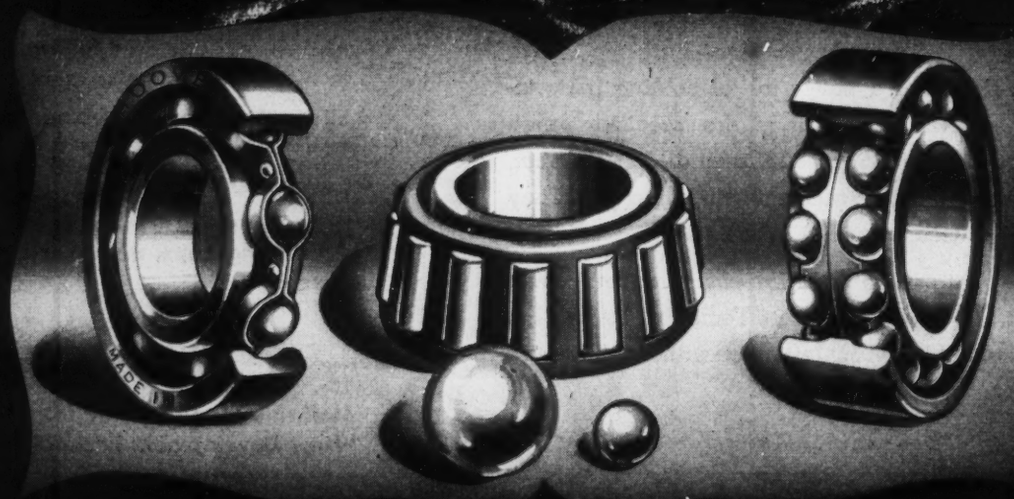
The Aristocrat of Bearings

FOR PRODUCTS WITH SUCH

HIGH STANDARDS *that* THEIR MAKERS

CAN AFFORD TO USE ONLY

THE FINEST BEARINGS



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The World's Only Ball Bearing with Honed Raceways

HOOVER BALL AND BEARING COMPANY -- ANN ARBOR, MICHIGAN

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835 Beacon St. (Kenmore 0411-0987)

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H. E. Rieckelman
416 Jackson Bldg. (Madison 2072)

CHICAGO 23, ILL.
G. D. Potter
Steel Sales Corp.
3348 S. Pulaski Rd. (Crawford 4400)

CLEVELAND 14, OHIO
Frank H. Grace
Frank H. Grace & Co.
1740 E. 12th St. (Main 2515)

DAYTON 1, OHIO
W. E. Campbell
P. O. Box 1041 (Fulton 6310)

DETROIT 9, MICH.
A. S. Kingerley
1411 Central (Vinewood 1-5000)

GRAND RAPIDS 2, MICH.
E. J. Campbell
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Republic Supply Co.
1400 Petroleum Bldg. (Fairfax 5310-0576)

LONDON, ONTARIO (CAN.)
Charles E. Norris
Unifin Tube Co.
1109 York St. (Metcalf 1698)

LOS ANGELES 21, CALIF.
Van D. Clothier
1015 E. 16th St. (Prospect 8326)

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G. H. Tobelman
C. E. Rinaman
60 E. 42nd St. (Murray Hill 2-8430)

PHILADELPHIA 2, PA.
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1208 Commercial Trust Bldg.
(Rittenhouse 6-1442)

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W. R. Harding
Supplies, Inc.
1214 Liverpool St. (Fairfax 6330)

RIDGEWOOD, N. J.
F. R. Meier
544 Morningside Rd. (Ridgewood 6-5826)

Scattered from coast to coast—located in the principal manufacturing centers of the country—are Wolverine representatives—not mere somebodies sporting Wolverine identities — but individuals thoroughly familiar with the tube industry, ready to work with you on any problems concerning tubing or its applications.

And backing each of these men — here at the Detroit Mill — is a supporting organization of trained engineers whose extensive experience can be drawn on to augment your own facilities.

WOLVERINE TUBE DIVISION

CALUMET & HECLA CONSOLIDATED COPPER COMPANY

MANUFACTURERS OF SEAMLESS COPPER & BRASS TUBING

1411 CENTRAL AVENUE • DETROIT 9, MICHIGAN

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GEARED POWER FOR INDUSTRY

THROUGHOUT America, in great and small production plants alike, wherever power turns the wheels of industry—Sterling Slo-Speed (Geared) Motors are leading the way to increased production records.

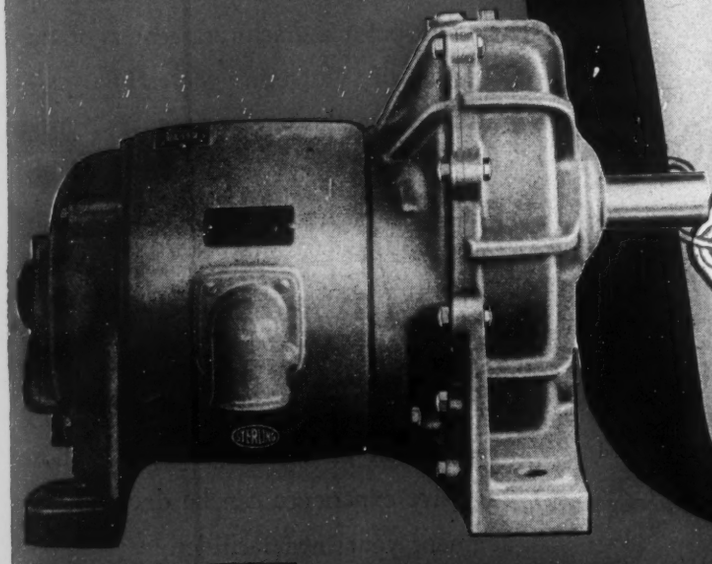
Sterling Slo-Speed (Modern Gear System) Motors give machinery manufacturers and production executives a complete power drive in one soundly engineered—compact—flexible—ultra efficient unit.

Write today for complete information

STERLING ELECTRIC MOTORS, INC.

NEW YORK • CHICAGO • LOS ANGELES

Representatives in Principal Cities



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H.P.—From 1/2 to 15

GEAR RATIOS—From 3:1 to 50:1

STERLING ELECTRIC MOTORS

for Greater Perform-ability

sm

GEAR HIGHLIGHTS

VOL. XI NO. 3

This is page 1 of the current issue. Write for the complete issue today.

ALSO IN THIS ISSUE

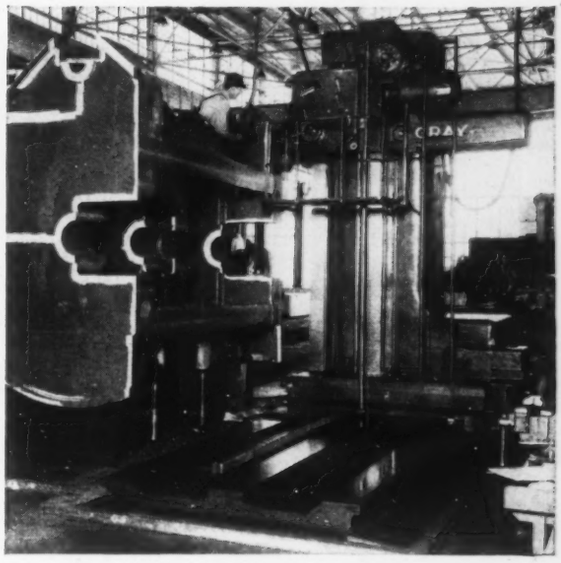
Underpass Curve—Shaving of Large Gears (Part II) ..... p. 2

Cone-Drives power Dorr Water Clarifiers ..... p. 3

New Gear Literature ..... p. 3

How to Design Better Gears in 10 Minutes ..... p. 4

NEW GRAY Boring, Drilling and Milling Machine FEATURES Self-locking CONE-DRIVE



The column and head assembly on this big Gray Horizontal weighs approximately 46,000 pounds, a big mass of accuracy that must be microjogged as little as 0.00025 inches at one time for accurate positioning of the tools. The column may be fed along the runway at speeds ranging from ½ to 120 inches per minute.

To accomplish all this in the Gray Horizontal Boring, Drilling and Milling Machine, Gray engineers selected a set of 7.500″ center distance Cone-Drive gears with a ratio of 40:1, to drive the pinion which meshes with the rack to propel and position the column along the runway. This particular set of Cone-Drives is self-locking,

(Continued on Page 3)

GEAR CHECKING RECORDERS AVAILABLE FROM STOCK

The versatile Michigan SINE-LINE gear checking recorder which makes a permanent chart record on gear checking machines is now available from stock.

The AY-1 Recorder may be used with Michigan SINE-LINE involute checkers, lead checkers, or the tooth spacing checkers. It may also be applied to a variety of additional checking operations such as recording variations in dimensions of thread forms, surface checking with parallels, and to many other checking operations wherein a precise record of dimensions is desired.

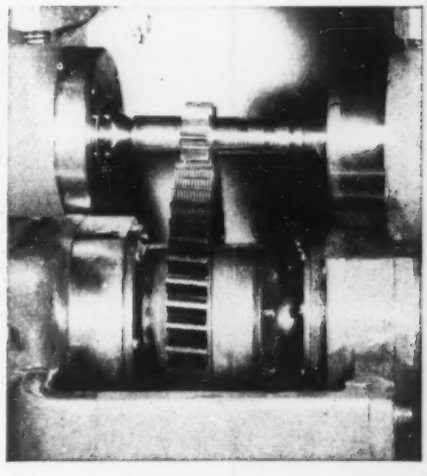
▼

COORDINATE TOOL DESIGN FOR MAXIMUM GEAR QUALITY

That best gear cutting results are obtained when pre-shave hobs and shaving cutters for any particular job are designed and engineered together is demonstrated again by the recent experience of one large producer of aircraft oil pump gears.

The operation involved the mass production of aircraft oil pump gears having a 7.1579 pitch and a

(Continued on Page 3)



MICHIGAN TOOL COMPANY 7171 East McNichols Road DETROIT 12, - - U.S.A.

It lets you talk...without a walk

IT'S easy to flash information from one room to another when offices are equipped with this new electronic intercom unit, made by Executone, Inc., New York. All it takes is the flick of a switch, and you can carry on a 2-way conversation with any of the other stations in the system. Combines complete privacy with facility for across-room reply.

Like many other successful instruments, the Executone employs a G-E Neon Glow Lamp as a pilot light. A glance tells you when the unit is on, because it has "*the glow that lets you know.*"

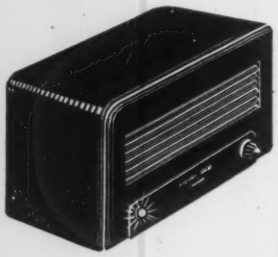
Pilot light is a type NE-51 G-E Glow Lamp. 1/25 watt.

...and it puts a "glow" in your sales story

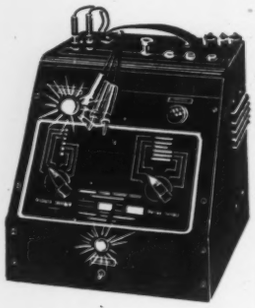
TYPICAL EQUIPMENT USING G-E GLOW LAMPS

DICTATION INSTRUMENT *uses glow lamp to show that recording is in progress.*

ELECTRONIC COUNTER *employs a number of glow lamps as panel indicators.*



OZONIZER. *The pilot light of this electronic air freshener is a G-E Glow Lamp.*



ANALYZER *uses neon glow lamps to indicate voltages in servicing refrigeration units.*

THE office equipment and electrical instruments shown here can only suggest the myriad ways General Electric Glow Lamps are used to add convenience, beauty, safety and sales appeal to electrical equipment of all kinds. To many a product designer the following G-E Glow Lamp features provide a clue to new profit possibilities:

1. Distinctive orange-red glow—high visibility.
2. Dependable long life—in some types up to 25,000 hours.
3. Low current consumption—as little as 1/25 watt.
4. Low brightness, low heat.
5. High resistance to shock and vibration.
6. Can be installed in small space.
7. Variety of sizes and wattages.
8. Operate directly from regular 105-125 and 210-230 volt circuits, AC or DC.

REMEMBER—*Every electrical device should have a live circuit indicator. G-E Glow Lamps are ideal for this purpose.*

SEND FOR free bulletin containing full information on G-E Neon Glow Lamps and their application to your product.

G-E LAMPS

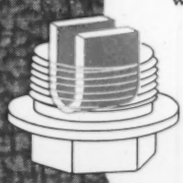
GENERAL ELECTRIC

Nela Specialty Div. Lamp Dept., 1 Newark St., Hoboken, N. J.

Your Product Deserves this Protection

Magnetic Plug Cuts Down Wear to Gears and Bearings

Gears and bearings in your product are in constant danger of premature failure due to the abrasive action of iron and steel particles which form in the lubricant as a result of ordinary wear. Lisle Magnetic Plugs eliminate this danger. Used in place of ordinary drain plugs, the Lisle Plug contains a powerful magnet which pulls abrasive metal out of the lubricant. Magnetic Plugs add greatly to the life and value of your product — yet they cost very little. Write for Free sample offer.

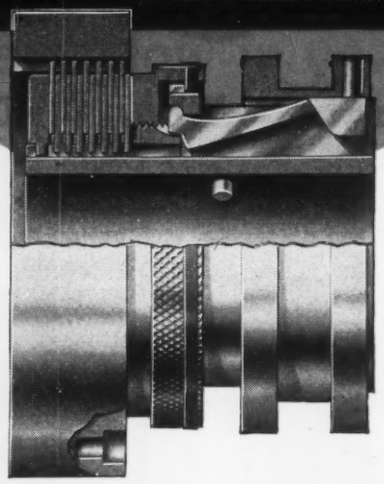


Lisle Magnetic PLUGS

Manufactured by LISLE CORPORATION
Box 1003 Clarinda, Iowa

MAXITORQ floating disc CLUTCHES

NOW ADAPTABLE TO ANY DRIVEN OR DRIVING MEMBERS



MAXITORQ RING TYPE DRIVING CUPS make it unnecessary to change bearing design to adapt Maxitorq Clutches to various types of driving or driven members. They are made to Standard specified limits to permit piloting the inside or outside diameter with pulley, fly wheel, sprocket, gear, sheave, etc. Bolt holes are counterbored to receive socket head cap screws for secure fastening.

It is far better for machinery manufacturers to use Maxitorq Cups than to make their own, both economically and for accuracy.

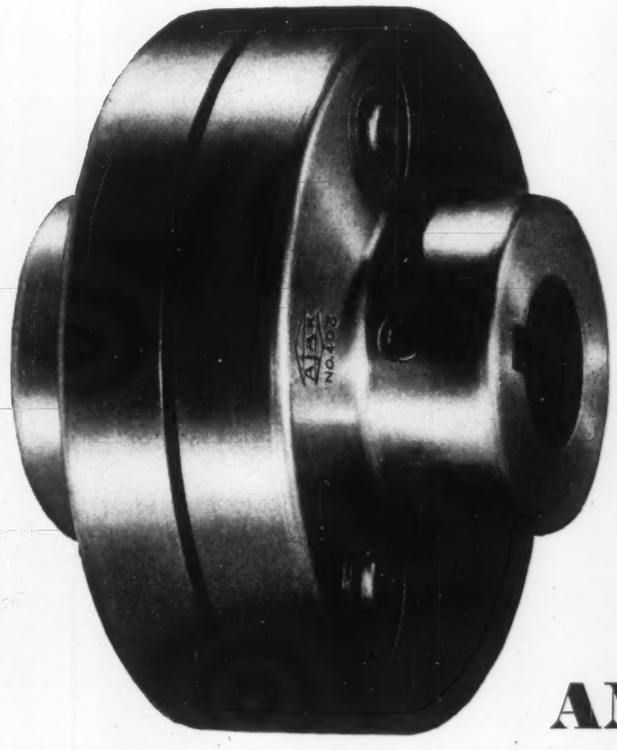
We have the precise tools and broaching fixtures to insure close tolerances and accurate alignment of slots.

MAXITORQ FEATURES

No tools whatsoever are required to adjust, take apart or assemble Maxitorq Clutches. Floating discs make certain that there's no drag, no abrasion, no heating when clutch is in neutral. Clutch is completely assembled on the body and shipped ready to slip onto a shaft. Standard Maxitorqs are in single and double types, wet or dry . . . also pulley and cut-off coupling types. Capacities to 15 H.P. at 100 r.p.m.

SEND FOR CATALOG NO. MD7

THE CARLYLE JOHNSON MACHINE COMPANY
MANCHESTER • CONNECTICUT



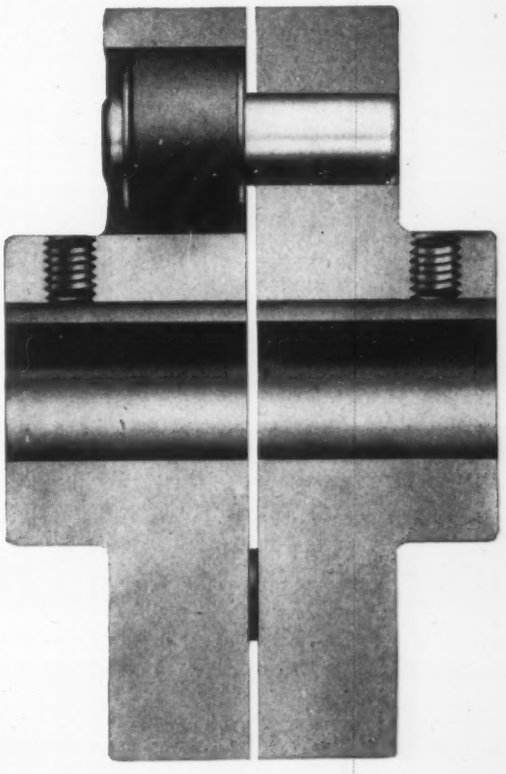
AJAX

Announces

AMERICA'S FINEST

LOW PRICED FLEXIBLE COUPLING

NO. 403



This new Ajax No. 403 Flexible Coupling is built on the same tried and true Ajax principles which have given satisfaction for over 25 years.

It is designed for small fans, centrifugal pumps, high speed end of speed reducers and other direct-connected installations where operating conditions are good, loads light and torques even.

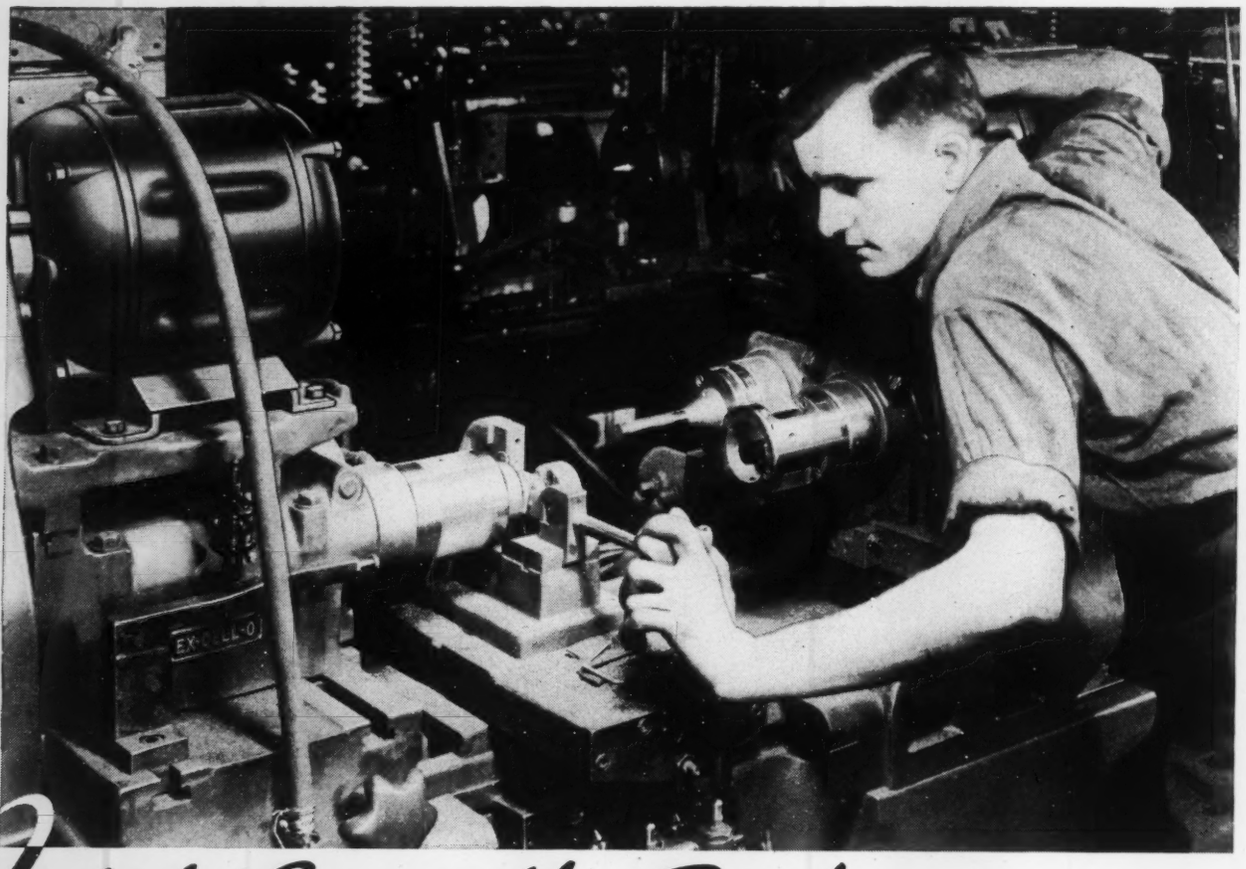
Positive, resilient drive . . . rubber-bushed . . . oilless bronze bearings mating with 3 drive studs provide protection against unavoidable misalignment.

Ajax No. 403 Couplings require no lubrication. They are quiet running, can be installed either horizontally or vertically and operate satisfactorily in abrasive laden air.

Write for Bulletin 101 and price.

AJAX FLEXIBLE COUPLING CO. INC.

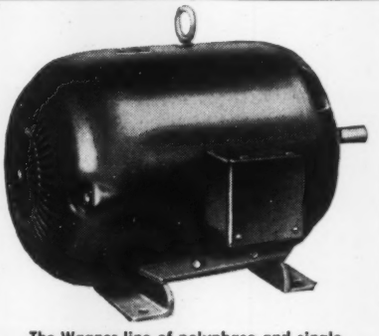
WESTFIELD, N. Y.



Quiet, Smooth Performance
that's what WAGNER *Quality* MOTORS *give your Machine Tools*

Wagner Quality Motors make a close machining job as easy as eating apple pie. They run "smooth as silk" and give performance that enhances the value of the machine tools they are driving.

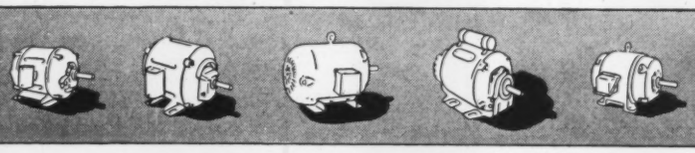
Because of smooth performance you find hundreds of thousands of Wagner Quality Motors on the job driving all types of industrial machines and equipment . . . That's why so many manufacturers have standardized on Wagner Motors. If you manufacture or use motor driven equipment Wagner can furnish the "RIGHT" Motor for your purpose. Users of Wagner motors also profit by our quick, convenient, nationwide service facilities. Twenty-nine branch offices, located in principal cities, are ready to give you service and advice. Contact our nearest office, or write Wagner Electric Corporation, 6404 Plymouth Ave., St. Louis 14, Mo., for bulletins on the complete line.



The Wagner line of polyphase and single phase motors is diversified to meet all machine tool requirements. Open-type and totally-enclosed non-ventilated motors are available with sleeve or ball bearings; totally-enclosed fan-cooled motors are built with ball bearings only.

Consult Wagner Engineers on all Electric Motor Problems

Wagner Electric Corporation
EST. 1891



M47-19

• ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES • AUTOMOTIVE PRODUCTS •

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PATTERNS?
Magnesium or Aluminum
CASTINGS?
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WELLMAN

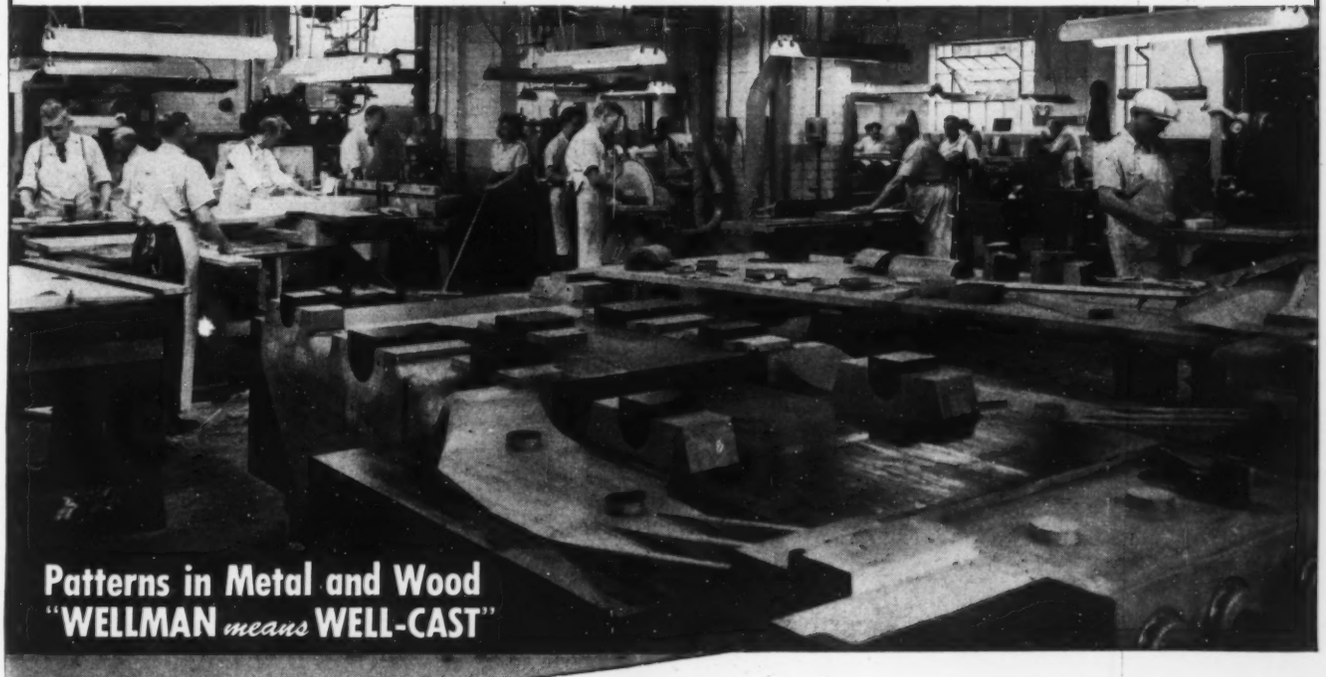
Because of our large pattern capacity, we make many patterns for outside foundries.

Production of patterns by men who work closely with the foundry is extremely important, as you realize, in obtaining accuracy for all metals, particularly magnesium.

We have complete facilities for making all sizes and designs of wood and metal patterns. Also magnesium and aluminum sand castings.

Send blue prints for quotation or let us know and we shall be glad to have a representative call.

A portion of our well-equipped pattern shop.



THE WELLMAN BRONZE & ALUMINUM COMPANY
GENERAL OFFICES:
2547 EAST 93rd STREET • CLEVELAND 3, OHIO
CASTINGS X-RAY INSPECTED

N • B • M BEARINGS
BETTER BEARINGS

N • B • M GRIDDED BEARINGS GIVE TRIPLE "BURN-OUT" PROTECTION

This is an enlarged cross-section of an N-B-M Gridded Bearing for Diesel engine and other high-speed, heavy-duty service. See how the 3 interlocked "layers" guard against bearing failure:

1. *.002" lead-tin alloy "run-in" surface,* electroplated in bore, increases resistance to seizure and corrosion.
2. *Precision-spaced grids* filled with N-B-M Silver Babbitt for: (a) "self-healing"—in case of overstress, melted babbitt flows over damaged area, restores bearing surface; (b) instant embedability—grit is safely trapped below surface.
3. *Centrifugally-cast lead-bronze shell* for: Greater strength, fatigue resistance • High thermal conductivity to equalize temperature • Conformability.

May we send complete engineering data?

N·B·M

AMERICAN Brake Shoe COMPANY

NATIONAL BEARING DIVISION
ST. LOUIS • NEW YORK

PLANTS IN: ST. LOUIS, MO. • PITTSBURGH, PA. • MEADVILLE, PA. • JERSEY CITY, N. J. • PORTSMOUTH, VA. • ST. PAUL, MINN. • CHICAGO, ILL.

HELPFUL LITERATURE

FOR DESIGN EXECUTIVES

60. Flexible Couplings

Lord Mfg. Co.—4-page illustrated bulletin No. 200-C describes complete line of one-piece flexible couplings which are available in seven sizes for loads from 1/16 to 1 horsepower and in miniature 1/50-horsepower rating for small load applications. Coupling consists of Neoprene core bonded to metal hubs and assures torsional flexibility, minimum assembly cost and other advantages.

61. Speed & Feed Calculator

Republic Steel Corp.—Dial type "Cutting Speed and Feed Selector" offers simple means for obtaining surface feet per minute and speed in revolutions per minute when stock diameter is known. Reverse side of calculator provides data to aid in machining various types of Enduro cold drawn stainless steels with different cutters, drills and tools.

62. Gaskets & Sealing Materials

Armstrong Cork Co.—20-page illustrated bulletin "Armstrong's Gasket and Sealing Materials" gives design and application data on wide range of materials which includes cork, cork-synthetic rubber, synthetic rubber and fiber compounds. Characteristics, composition, uses, forms and sizes are tabulated. Engineering data cover design considerations.

63. Timing Motor

R. W. Cramer Co.—4-page illustrated bulletin No. 10 gives application data, salient features, design details, characteristics, speed ranges and dimensions of type SX synchronous timing motor. Gear trains can be furnished to deliver speeds from 1 revolution per 24 hours to 60 revolutions per minute.

64. Variable Speed Drive

Raytheon Mfg. Co.—6-page illustrated bulletin describes Servotron electronic variable speed drive which provides usable speed range in ratios up to 100:1 and flat speed regulation from no load to full load. Consisting of transformer, control unit, direct current motor and control station, drive is available in capacities up to 1 horsepower.

65. Precious Metals

D. E. Makepeace Co. — 4-page illustrated folder "Makepeace Laminated and Sol'd Precious Metals for Industrial Use" describes fabricated parts and assembly service, bar contact materials and precious metal solders offered by this company.

66. Tracing Material

Industrial Sales Div., Eastman Kodak Co.—4-page illustrated folder "Kodatrace" presents information on this translucent tracing material. Material is made of safety base film tinted blue and has fine grained matte surface suitable for use with pencil or ink.

67. Multiple Arm Relays

Signal Engineering & Mfg. Co.—4-page illustrated bulletin No. 30 presents information on line of heavy duty multiple-arm relays. Data are given regarding basic design features, contact ratings, circuit arrangements and other pertinent information.

68. Strainers

A. W. Cash Valve Mfg. Corp.—4-page illustrated bulletin No. 224 presents data on types S and SY strainers for protection of pipelines carrying steam, air, gas or liquids. Size, price and specification data are listed and recommended applications and construction features are described.

69. Manufacturing Facilities

Alden Products Co.—68-page illustrated looseleaf bulletin outlines design, engineering and manufacturing facilities of this company which specializes in electrical and electronic assemblies and subassemblies. Described are tool and die rooms, plastic molding and finishing departments, assembly facilities, machine shop and other departments. Typical electrical components regularly manufactured are described.

70. Thermostats

Fenwal Inc.—54-page illustrated loose-leaf type handbook of thermal procedure covers design and layout of temperature detection and control equipment. Complete line of Thermoswitch thermostats is covered, modifications explained, features outlined and applications and specifications given.

71. V-Belt Sheaves

Browning Mfg. Co.—20-page illustrated booklet form No. 851 describes line of Gripbelt V-belt sheaves with split taper bushings in 731 stock sizes. Dimensional data and prices are given.

72. Balancing Machine

Taylor Mfg. Co.—6-page illustrated bulletin No. 761 discusses importance of eliminating forces causing vibration by balancing product. Capacities and functions of Hi-Eff static universal balancing machine are covered.

73. Cast Stainless Steel

Empire Steel Castings Inc.—4-page bulletin No. 145-S is designation chart for cast corrosion resistant and heat resistant stainless steels. It lists type numbers, principal alloying elements, typical mechanical properties and other data.

74. Ceramic Parts

American Lava Corp.—8-page illustrated bulletin No. 144 is technical booklet entitled "Designing Steatite Ceramics" in which design considerations relative to extruded and die pressed ceramic parts are outlined. Typical parts are shown.

75. Surface Treatment

Parker Rust Proof Co.—44-page illustrated brochure form No. A1221 describes Bonderizing process that produces surface which holds paint to metal and resists corrosion. Typical and recommended applications, advantages, methods of application, technical data and other information are presented.

76. Magnetic Pulleys

Stearns Magnetic Mfg. Co.—24-page illustrated catalog No. 303 presents complete information on applications, selection of suitable types and advantages of Stearns magnetic pulleys and magnetic pulley separators.

77. Oil Distributing Bushings

Moccasin Bushing Co.—4-page illustrated bulletin form No. 2-47 describes oil distributing bushings for Saco-Lowell, Whitin and H. & B. cards. Suggested piping layout is shown.

FOR MORE INFORMATION

on developments in "New Parts" and "Engineering Department" sections—or if "Helpful Literature" is desired—circle corresponding numbers on either card below.

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78. Constant Speed Motors

Westinghouse Electric Corp.—4-page illustrated folder No. 3100-2-CSP deals with squirrel-cage type CSP Life-Line motors of dripproof construction in ratings from ½ to 20 horsepower for operation on 2 and 3-phase, 60/50/25-cycle, 208/220/440/550-volt current.

79. Industrial Pumps

Marine Products Co.—4-page illustrated bulletin shows and gives brief specifications for line of bronze centrifugal pumps for industrial and other purposes.

80. Magnetic Materials

Allegheny Ludlum Steel Corp.—32-page illustrated brochure No. EM 18-Ed provides clear explanation of basic functions of magnetic core materials, their range and variety in covering needs of the electrical industry. Application chart for magnetic core materials is included and specifications given.

81. Industrial Coatings

Bradley Paint Engineers Inc.—8-page illustrated pocket-size booklet "Engineered Paint plus . . . Engineered Application" describes entirely new service for industrial users in which both paint and its application are engineered to specific requirements.

82. Power Plant Controls

Taylor Instrument Cos.—4-page illustrated folder No. 98149 presents diagrams, specifications and operating data on automatic blowdown control system. Use of Taylor instruments in desuperheater control system, recording exhaust steam and heating system return temperatures, deaerating feedwater control system and applications to produce definite power plant savings are described.

83. Seamless Steel Tubes

Steel & Tube Div., Timken Roller Bearing Co.—8-page illustrated bulletin No. S237 lists finishes and sizes of available seamless steel tubes for mechanical applications. Listed also are diversified uses for mechanical tubing.

84. Color Dynamics

Pittsburgh Plate Glass Co. — 32-page illustrated brochure "Color Dynamics" reveals how color is currently being employed to promote continuity of employment, improve efficiency of operation and maintain quality of production. Individual sections are devoted to use of color on machinery and equipment; on walls and ceilings; and on floors, aisles and mobile equipment.

85. Fastening Devices

Allmetal Screw Products Co.—84 page illustrated catalog No. 44 presents complete data on line of stainless steel fastening devices which includes bolts, cap screws, nuts, pipe fittings, plugs, pins, rivets, screws, washers and other similar parts. Engineering reference section deals with factors related to stainless steel fastenings and their application.

86. Solenoids

Practical Electric Co.—4-page illustrated folder describes solenoid consisting of only five component parts: base, armature, coil, coil locks and back stops. Armature is designed with self-contained built-in pusher which makes solenoid adaptable to push or pull work.

87. Shoe Type Brakes

Clark Controller Co.—4-page illustrated bulletin No. 106 presents features, application and general description of direct current shoe type series or shunt wound brakes designed for use on heavy duty applications such as hoists, general mill auxiliaries, etc. Installation adjustments, torque, shoe clearance, bearing pressure, linkage design and mechanical release are described in detail.

88. Threaded Inserts & Studs

National Screw & Mfg. Co.—18-page illustrated booklet "Ring Locked Rosan Locking System" describes how lock ring, accurately serrated both inside and out, engages its inner teeth with mated serrated collar on insert stud to complete permanent installation. Twelve types of inserts and studs are covered and complete specifications are listed for each.

89. Lubrication Equipment

Essex Brass Corp.—96-page illustrated catalog No. 7 describes and presents prices of sight feed, automatic and plain lubricators; brass and glass oilers; hand oil pumps; grease cups; oil and water gages; gage and air cocks; oiling devices; tube fittings and other lubricating devices.

90. Air Filtration

American Air Filter Co.—23-page illustrated booklet "American Air Filters in Industry" discusses various types of industrial dust problems and typical applications of air filters to solve them. Included are chart of size and characteristics of air-borne solids and sections dealing with atmospheric dust.

91. Variable Resistors

P. R. Mallory & Co.—12-page illustrated engineering data folder contains engineering data, electrical and mechanical characteristics, taper charts and dimensional drawings for various types of carbon and wire-wound variable resistors and pad attenuators.

92. Hydraulic Equipment

Parker Appliance Co.—8-page illustrated catalog "Fluid Power" deals with available tube couplings, valves, fabricating equipment and industrial appliances, and applications of hydraulic equipment for industrial uses. Manufacturing facilities are presented.

93. Industrial Clutch-Brake Unit

Warner Electric Brake Mfg. Co.—4-page illustrated folder "Presenting the Warner 'ICB Unit'" describes and contains application engineering data on combination clutch-brake unit which operates electrically. In addition to ordinary friction, it employs power of electromagnetic attraction between ring shaped electromagnet and armature disk to provide starting or stopping power.

94. Diesel Engines

Witte Engine Works—20-page illustrated catalog No. 11 contains information on line of vertical and horizontal diesel engines in sizes from 4 to 12 horsepower and diesel-electric plants in corresponding sizes. Features of construction and installations under varying conditions are shown.

95. Valve Cross Reference

Ohio Injector Co.—20-page valve cross reference chart contains complete listing of OIC valve numbers in order and description of line of steel, iron and bronze valves for fluid service.

96. Solid Frame Solenoid

Phillips Control Corp.—8-page illustrated bulletin No. 6 presents diagrams and performance curves on line of Phil-trol actuators. These small compact solid frame solenoids develop unusual power.

97. Coolers

Ross Heater & Mfg. Co.—24-page illustrated bulletin No. 5322 presents complete information on types CP and CF coolers designed for continuous service for lubricating, cutting, quenching and transformer oils; oil pump systems; hydraulic presses; engine jacket water; refrigerant emulsions; small vapor condensers and similar uses.

98. Network Protectors

General Electric Co.—39-page illustrated bulletin No. GEA-2017C presents detailed account of construction, applications and maintenance requirements of network protectors for alternating current secondary systems. Uses, accessibility and special features are outlined.

99. Magnetic Starter

Arrow-Hart & Hegeman Electric Co.—4-page illustrated bulletin describes new type RA size 2 magnetic starter for up to 25 horsepower on polyphase service and up to 10 horsepower on single phase motors. Control incorporates balanced mechanism, it is easy to wire, and contacts align perfectly. Arc is minimized.

100. Extruded Continuous Hinges

Moynahan Bronze Co.—74-page illustrated plastic-bound design data book describes line of extruded continuous hinges made of aluminum. Physical, mechanical and chemical properties, details of standard hinges, tracing standards, load tests and deflection curves and hinges of copper base alloys are covered. Interleafed tracing forms are included to aid designers.

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2	22	42	62	82
3	23	43	63	83
4	24	44	64	84
5	25	45	65	85
6	26	46	66	86
7	27	47	67	87
8	28	48	68	88
9	29	49	69	89
10	30	50	70	90
11	31	51	71	91
12	32	52	72	92
13	33	53	73	93
14	34	54	74	94
15	35	55	75	95
16	36	56	76	96
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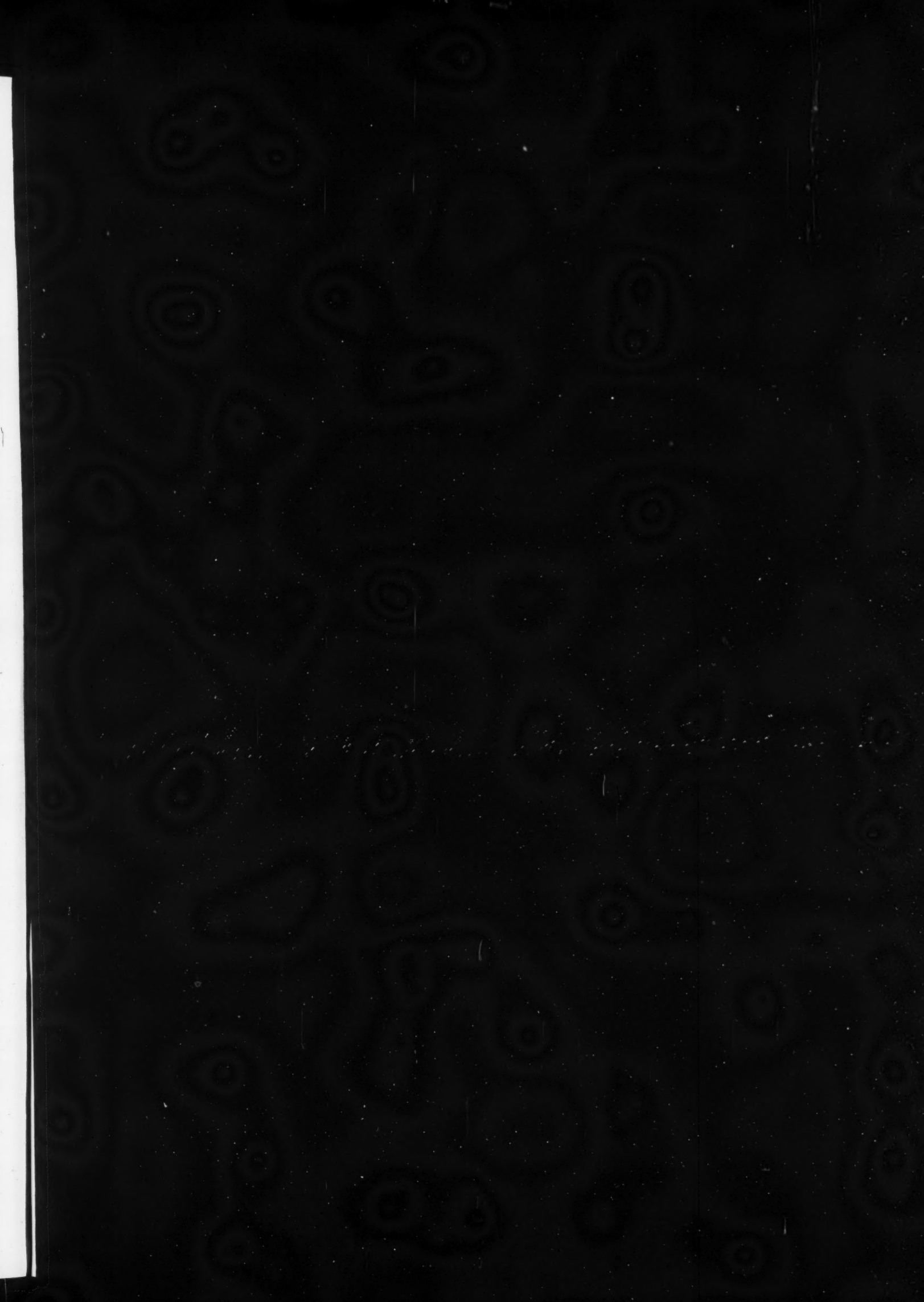

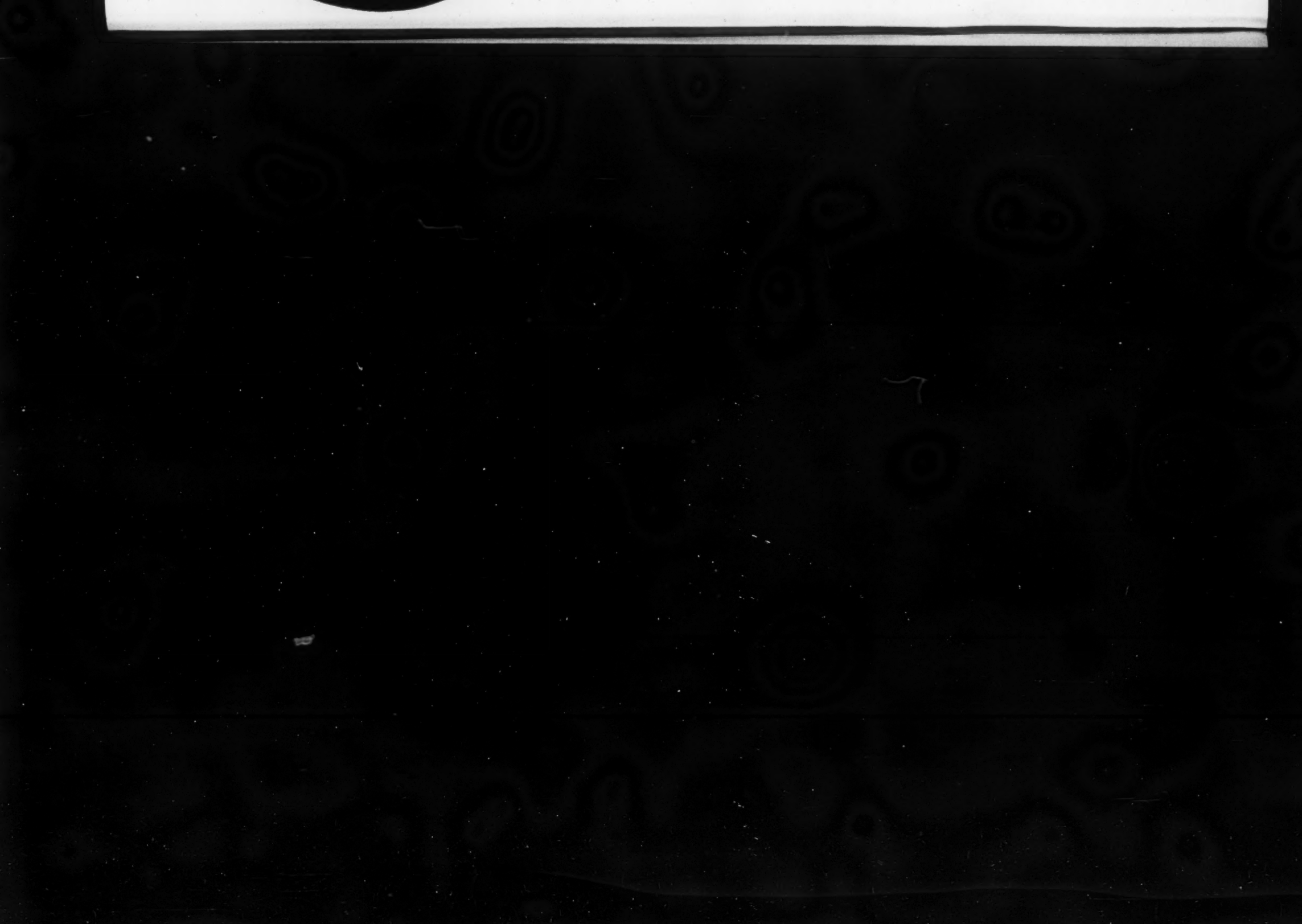

Unretouched photo of Tube Turns forging right off the press

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This drive gear forging is a relatively big specimen of the "round jobs" which are a TUBE TURNS specialty. It weighs forty-five pounds, measures nearly thirteen inches across, and was produced on a TUBE TURNS high-speed mechanical press.

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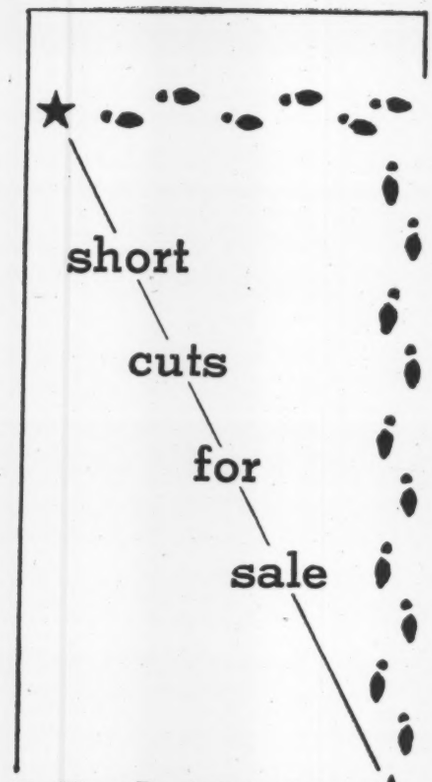

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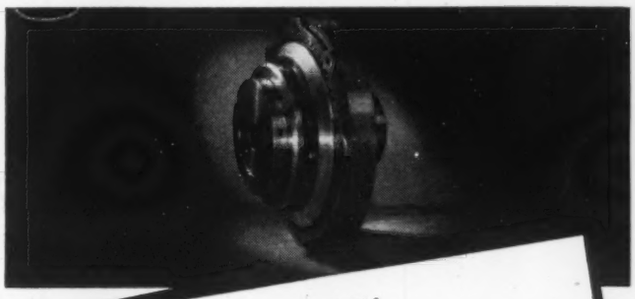

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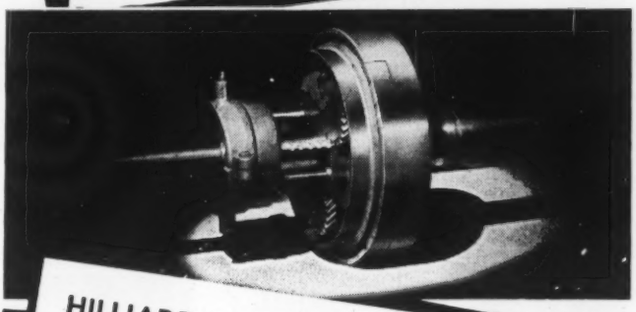

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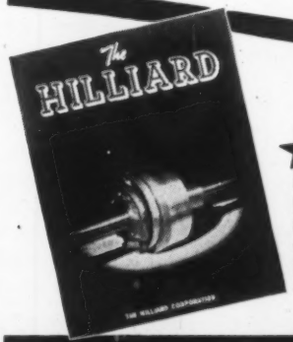

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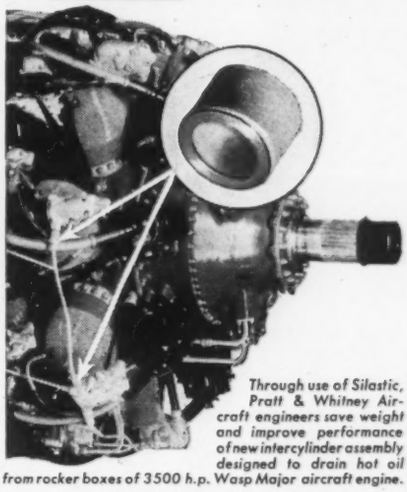

Through use of Silastic, Pratt & Whitney Aircraft engineers save weight and improve performance of new intercylinder assembly designed to drain hot oil from rocker boxes of 3500 h.p. Wasp Major aircraft engine.

SILASTIC* solves another aircraft problem

Silastic *stays elastic* in arctic cold or oven heat. Unlike any other rubber-like material, Silastic is built on an inorganic framework and has unique properties which enable design engineers to solve many a troublesome problem.

Pratt & Whitney Aircraft engineers, for example, had to design an intercylinder assembly to drain hot oil from the 30 rocker boxes on the underside of the 28-cylinder Wasp Major. Metal tubing, of course, but between the tubing and the rocker boxes an elastic connector—serviceable at temperatures up to 300°F. in contact with hot oil—was necessary to absorb the relative motion between engine cylinders.

That problem of elasticity at high temperatures has plagued design engineers for generations. Pratt & Whitney Aircraft engineers, however, knew about heat-stable, oil-resistant Silastic. They had used gaskets of Silastic to seal the 56 rocker boxes of the Wasp Major.

So they designed connectors of Silastic with metal couplers to attach the tubing to the rocker boxes. A great deal of weight was saved; heat was more easily dissipated through the all-metal exterior of the assembly; and performance standards were improved.

The Silastic connectors for this job were molded of Silastic 181 by the Connecticut Hard Rubber Company of New Haven. Other Silastic stocks, serviceable over a temperature range of —70° to 350°F. continuously—up to 500°F. in intermittent use—are described in leaflet No. B 21-1.

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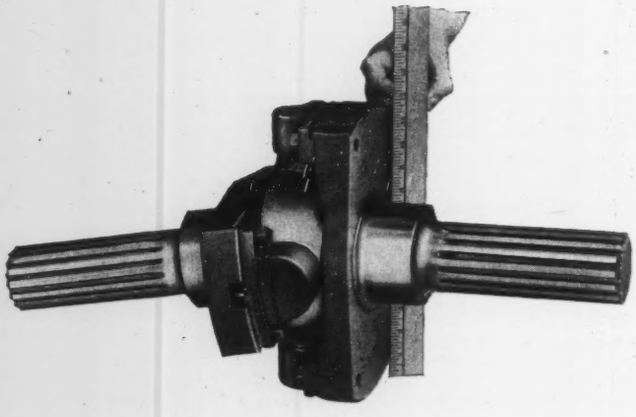

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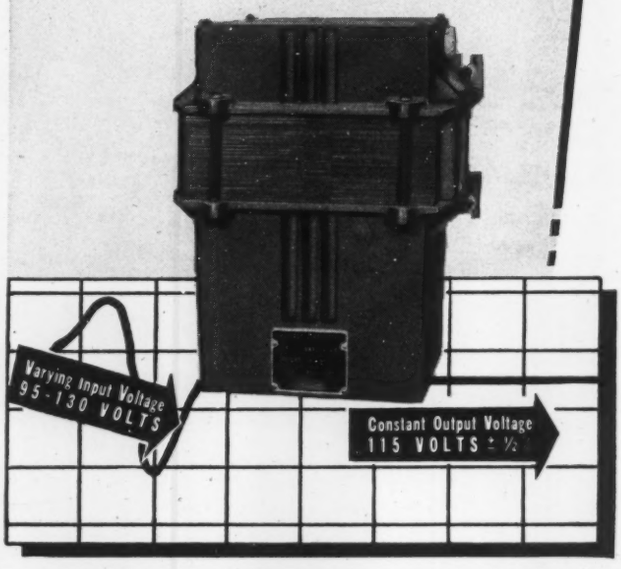

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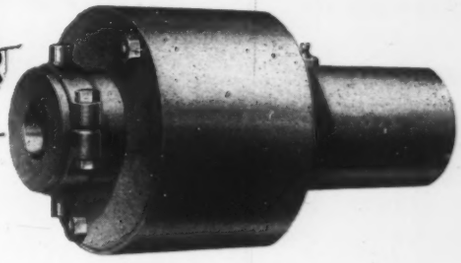

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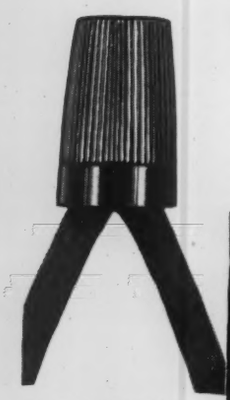

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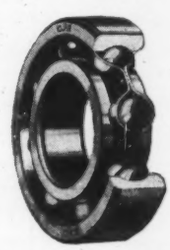

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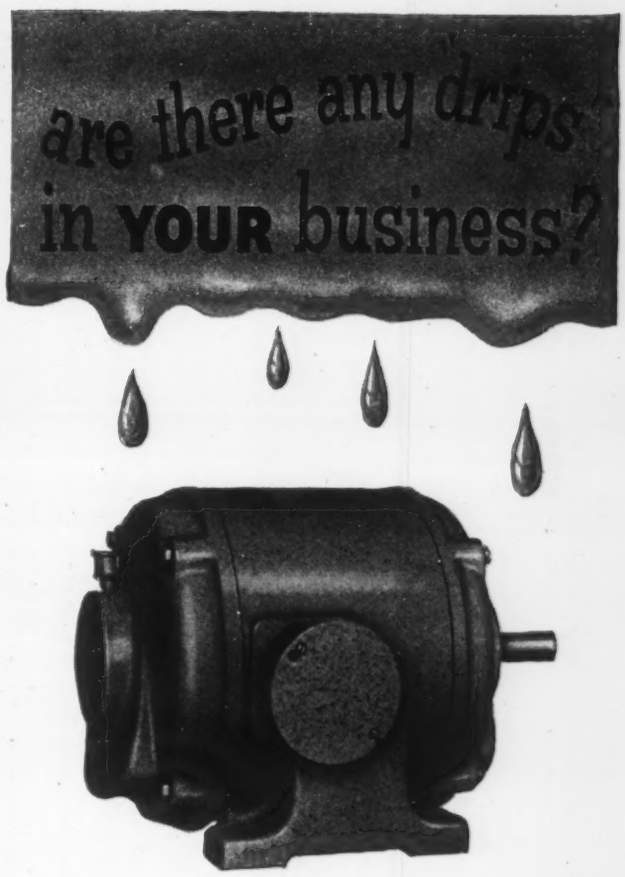
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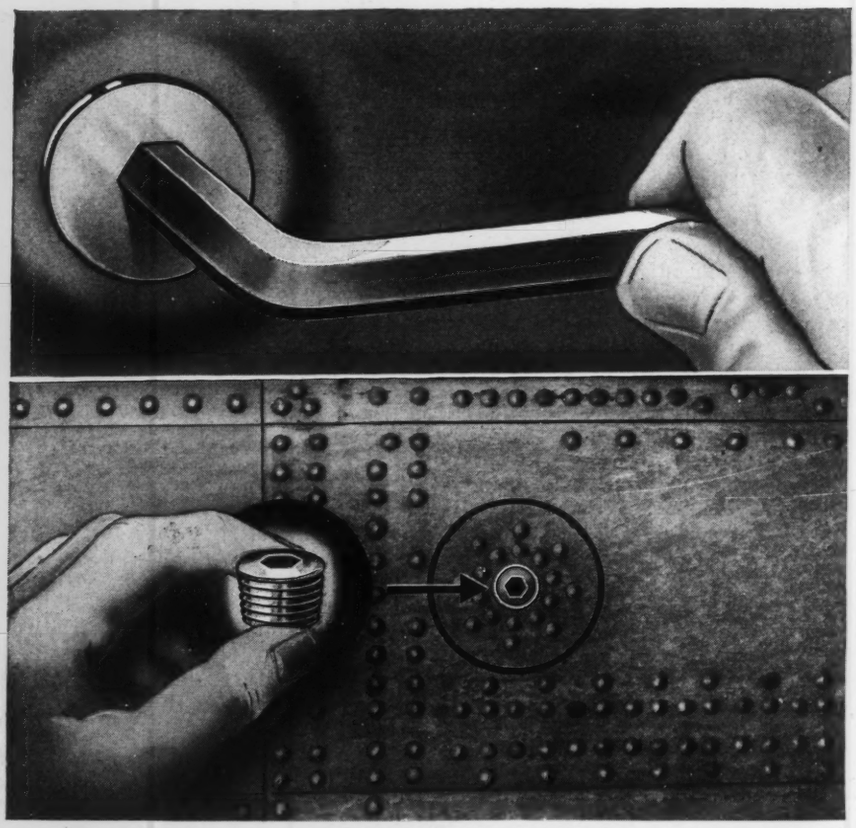

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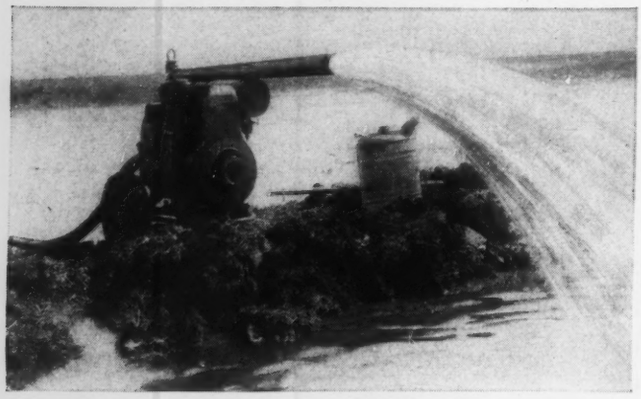

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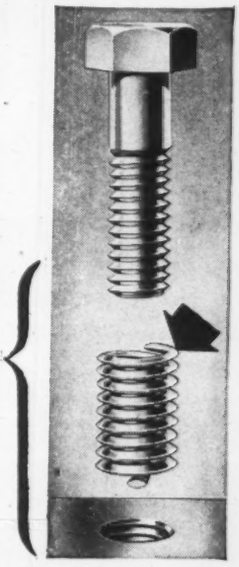

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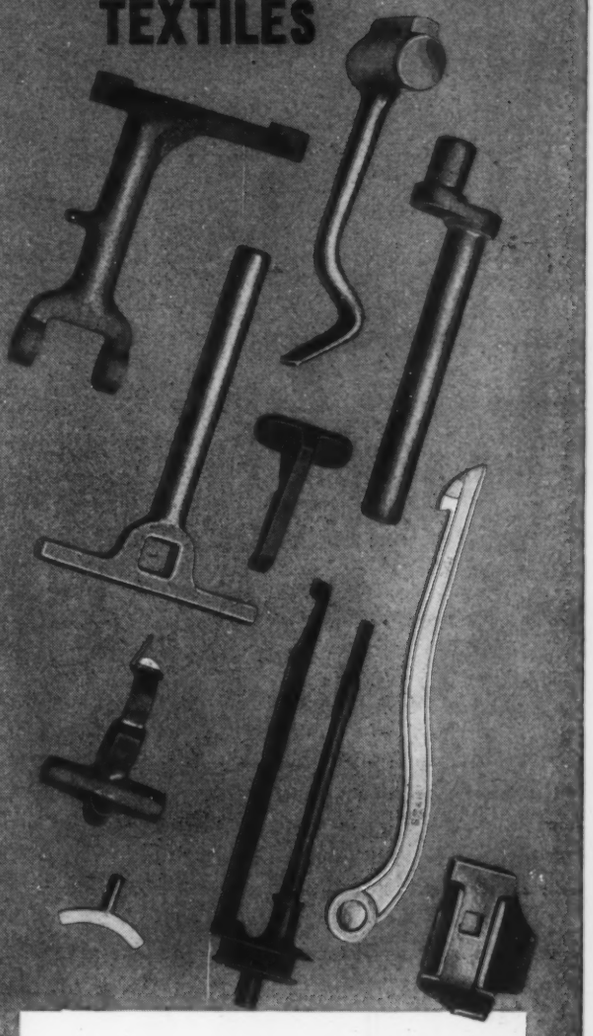

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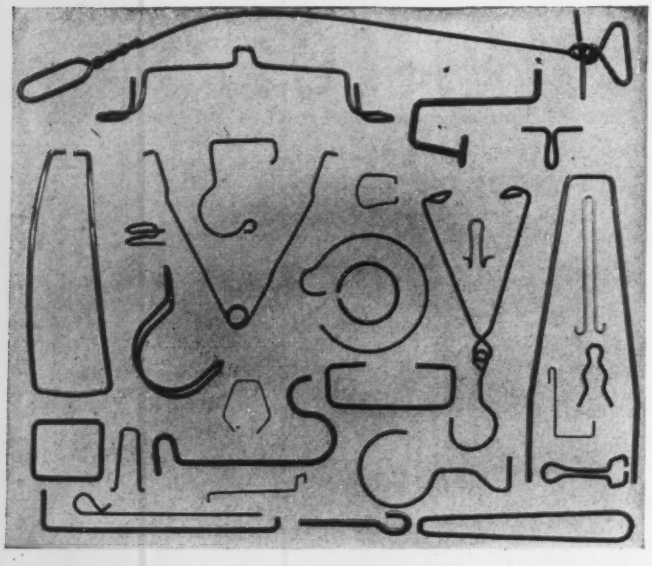

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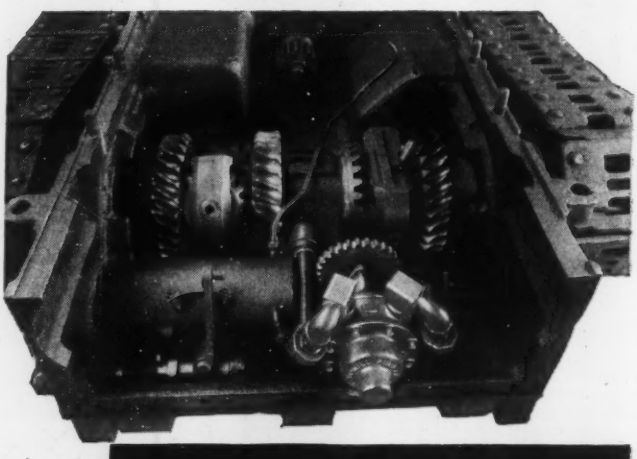

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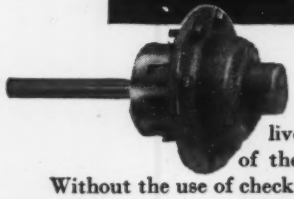

Drive it clockwise. Drive it counter-clockwise. This Tuthill Automatic Reversing Pump delivers from the same port regardless of the direction in which it is driven. Without the use of check valves, it provides the dependable pumping equipment for use where drive shaft reverses (as illustrated) or where the ultimate direction of shaft rotation is not known. Ideal for lubrication, coolant and liquid transfer service. Capacities up to 200 g.p.m. in wide pressure ranges. Write for Tuthill Model R bulletin.

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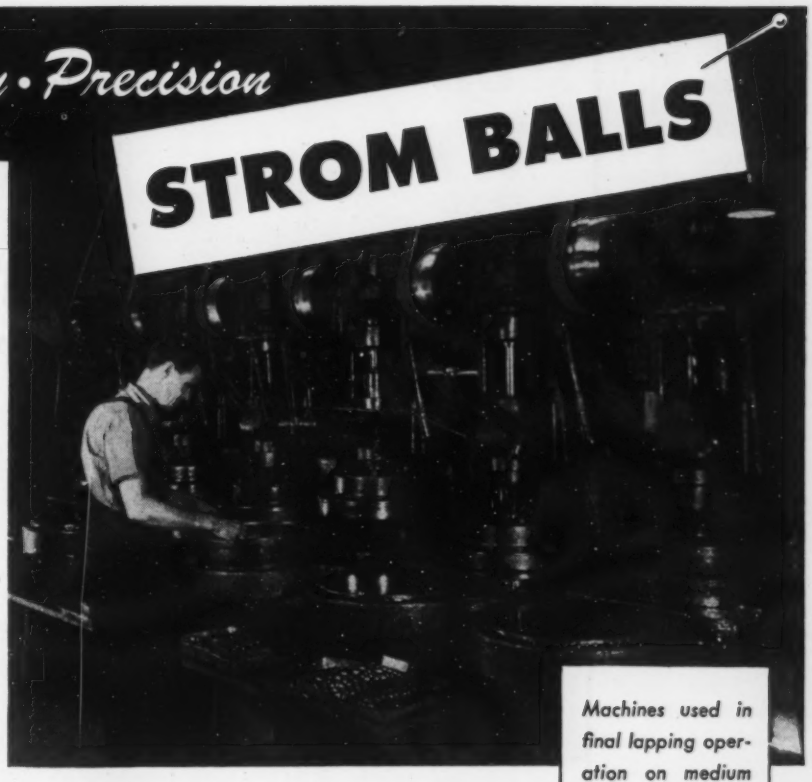

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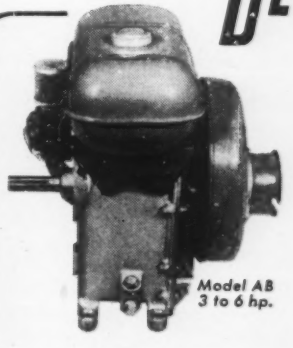

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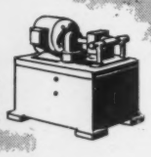

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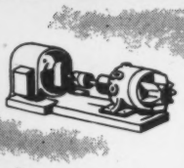

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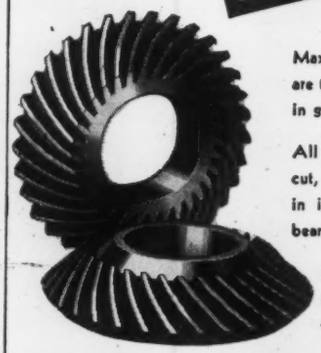

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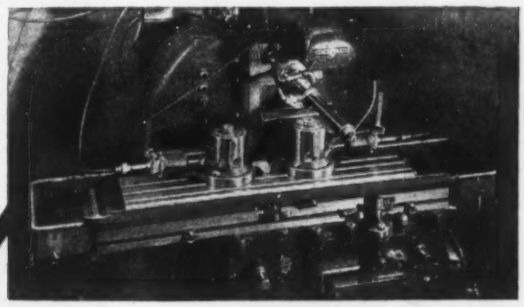

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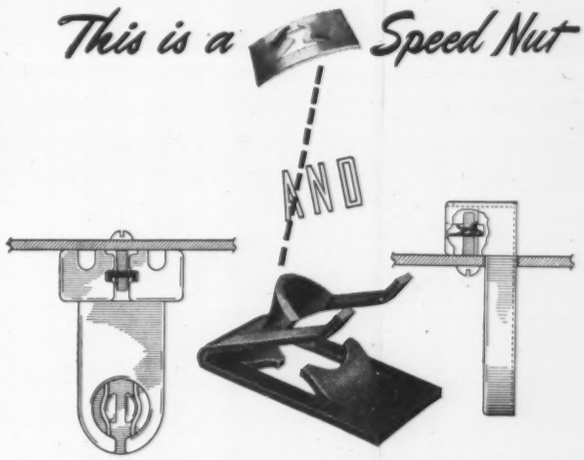

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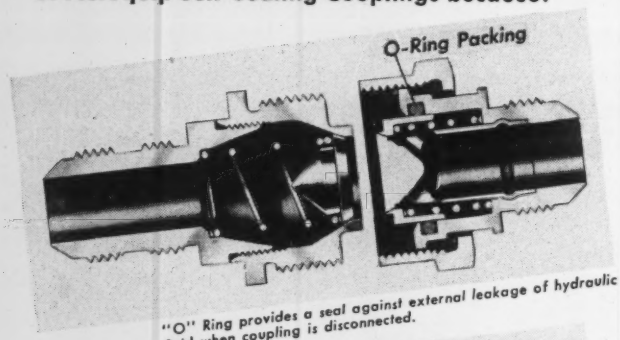
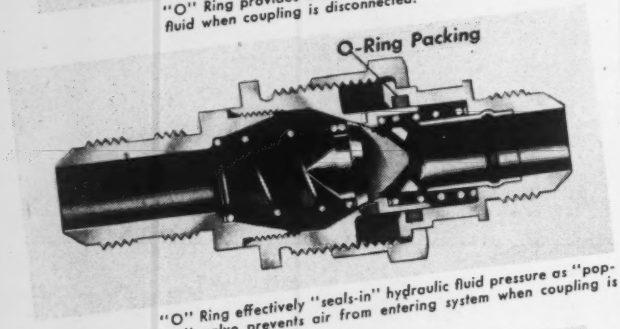
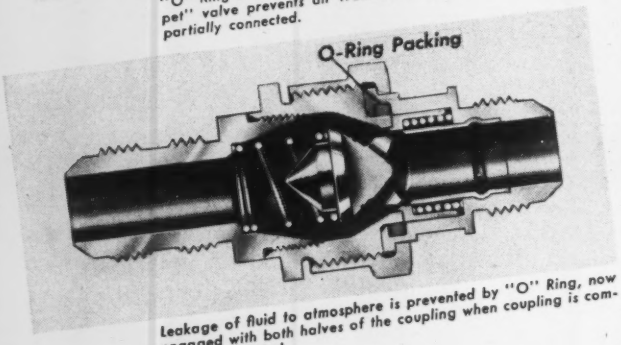
Linear "O" Rings are incorporated in the design of Aeroquip Self-Sealing Couplings because:



"O" Ring provides a seal against external leakage of hydraulic fluid when coupling is disconnected.



"O" Ring effectively "seals-in" hydraulic fluid pressure as "poppet" valve prevents air from entering system when coupling is partially connected.



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Covered by Christensen U. S. Patent No. 2,180,795; all "O" Rings sold by Linear are manufactured under royalty agreement with patentee.

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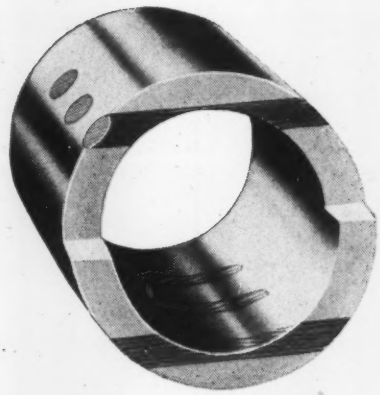

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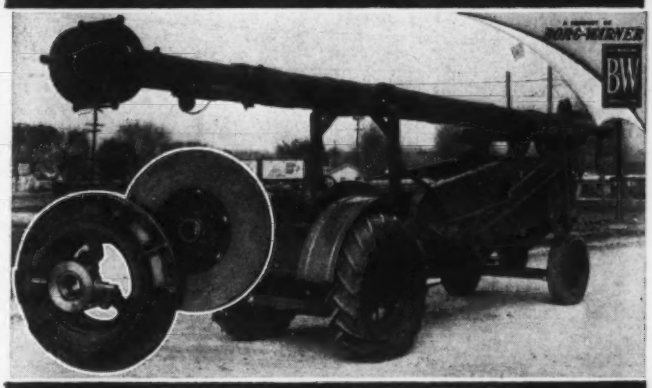

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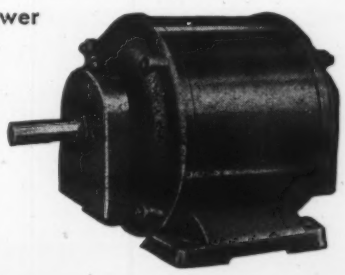

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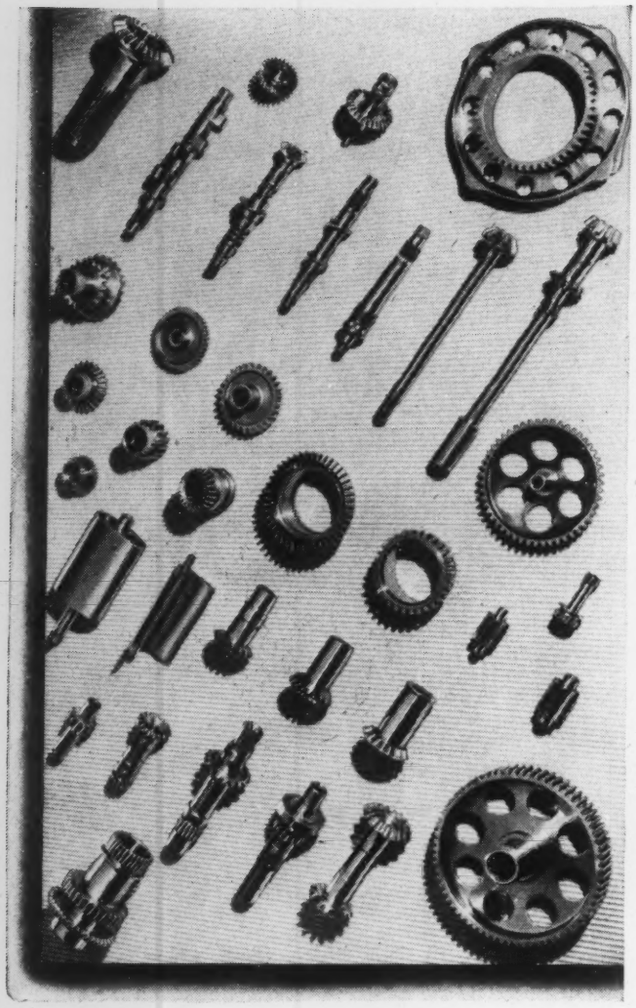

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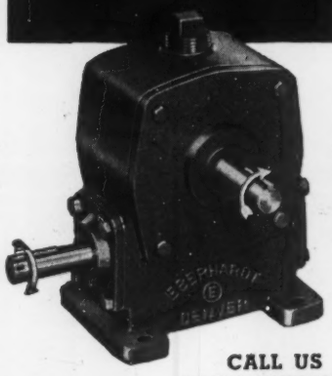

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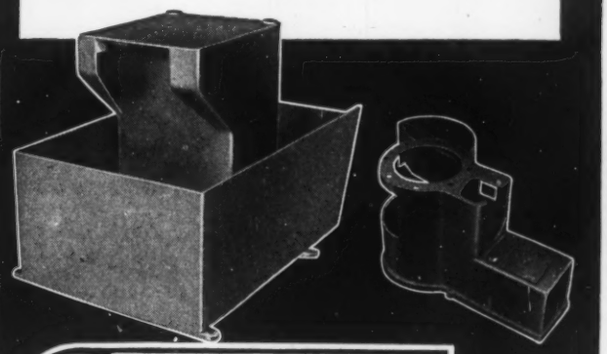

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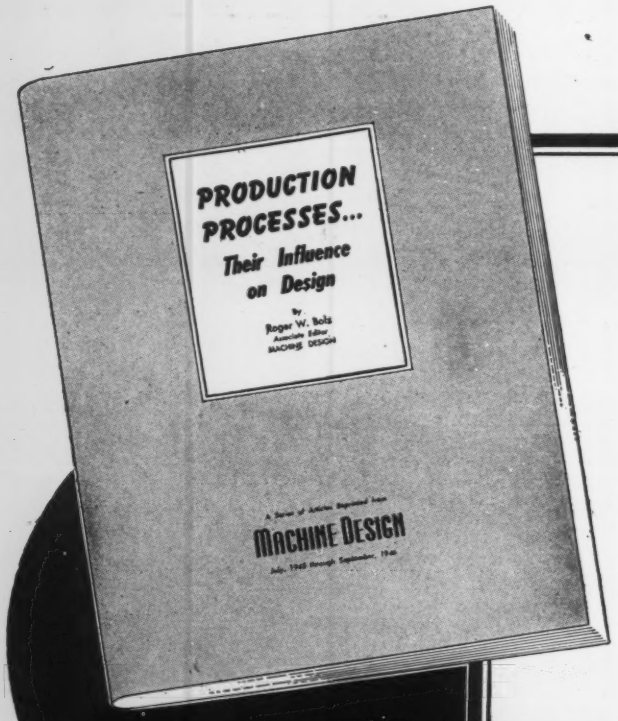

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Associate Editor, MACHINE DESIGN

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Erasures are made easily, without damage. It gives sharp, contrasting prints of the finest lines. It resists the effects of time and wear, and does not become brittle or opaque.

Imperial Pencil Tracing Cloth is right for ink drawings as well.

IMPERIAL PENCIL TRACING CLOTH

SOLD BY LEADING STATIONERY AND DRAWING MATERIAL DEALERS EVERYWHERE

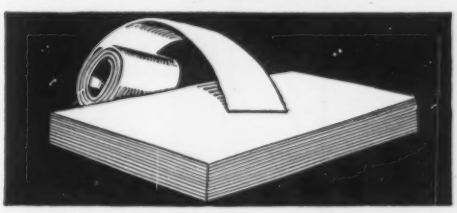
INCLUDE IT....

"ELEPHANT BRAND"
PHOSPHOR BRONZE

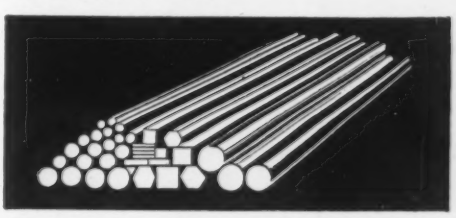
...in your design
SPECIFICATIONS

Really a very "versatile" alloy, "Elephant Brand" true Phosphor Bronze offers: great strength; hardness; resistance to corrosion, wear, abrasion, fatigue and break-down under arcing,—also it's non-magnetic, and a good conductor. Write for Literature and Details.

WIRE in coils for spring manufacturers; Flat wire in coils or lengths; Tinned binding, for armature work; Straightened (round), in lengths. All wire can be supplied bright-annealed.



SHEETS in rolls; Slit sheet metal, tinned both sides—in various gauges and tempers covering a broad range of uses.



RODS up to 6" diameter, in Round, Square and Hex . . . available now for prompt delivery.

Elephant Brand Phosphor Bronze has been used by thousands of manufacturing firms in all branches of industry for nearly three-quarters of a century—Since 1874 manufacturers of nothing else but Phosphor Bronze.

STRIP • SHEET • RODS • CASTINGS • WIRE • BUSHINGS

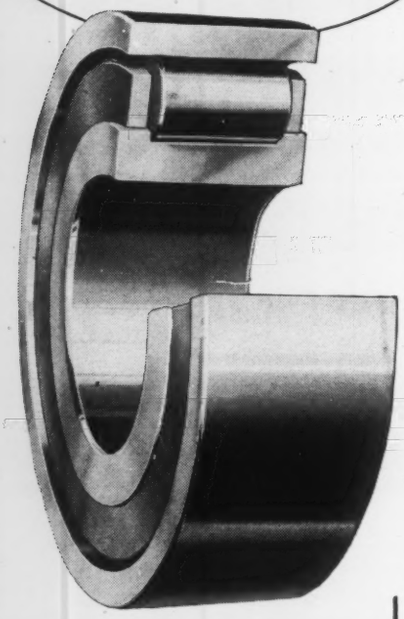
THE PHOSPHOR BRONZE SMELTING COMPANY
2200 WASHINGTON AVE., PHILADELPHIA, PA.
"Original manufacturers of Phosphor Bronze in the U.S.A."—Established 1874

Install Them and Forget Them!

AMERICAN

RADIAL

Roller Bearings



AMERICAN RADIAL ROLLER BEARINGS are engineered to exacting standards that result in better performance and minimum maintenance.

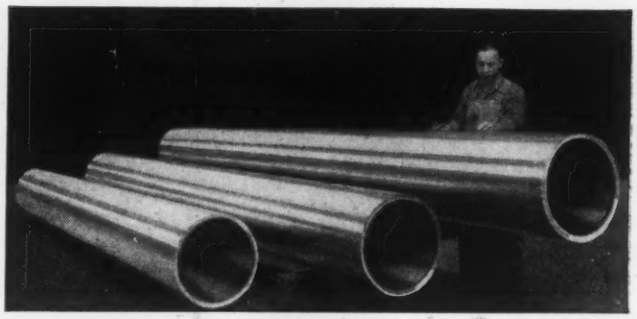
Furnished in 5 styles, 6 S.A.E. series and 85 sizes. Special designs also available. Write.

AMERICAN ROLLER BEARINGS HEAVY DUTY

AMERICAN ROLLER BEARING CO.

420 Melwood Street Pittsburgh, Pa.

Pacific Coast Office: 1718 S. Flower St., Los Angeles, Calif.



Merited Leadership

Design, Maintenance Engineers and Purchasing Agents have specified Sandusky Centrifugally Cast bronze, brass and Monel sleeves, liners, bushings, tubes, bearings, roll covers and rings on all equipment for over 30 years. Sandusky is the pioneer in this specialized field and these years of experience are as much a part of every casting as the quality material and superior workmanship.

For size ranges see "Sandusky" in directory section "Iron, Steel and Nonferrous Metals listed by Tradenames".

Specify SANDUSKY on your next application.

Write for Bulletin 540.

CHIEF SANDUSKY *CENTRIFUGAL CASTINGS*

SANDUSKY FOUNDRY AND MACHINE CO. SANDUSKY OHIO, U.S.A.

DRILL JIG BUSHINGS

Accurate Interchangeable Concentric

WRITE FOR FREE CATALOG

Acme Industrial Company

211 N. LAFLIN STREET, CHICAGO 7, ILLINOIS

If your men are forced to stand around like this-because your pumps are slow and inefficient . . . .

Then-

DON'T WASTE TIME!

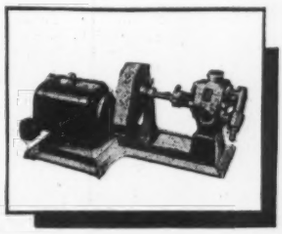
Investigate

VIKING ROTARY PUMPS

Today!

It's Viking for fast and positive delivery, self-priming, no pulsation, dependable long life.

Write for special Bulletin Series 46SH. It will be sent to you by return mail.



See Our Catalog In SWEETS

VIKING Pump COMPANY
CEDAR FALLS, IOWA

Delivery NOW!

Priced at a NEW LOW! Solve price and assembly problems with the 292 Pointer Knob, available now in several variations . . . in large quantities . . . priced right. It's the leader in a full line of standard plastic knobs and control balls for electrical, electronic and industrial use.

Put your plastic knob and control problems up to the largest producer in the industry—Kurz-Kasch. Write for illustrated Catalog 103-A which lists specifications and descriptions of the whole Kurz-Kasch standard line.

Kurz-Kasch, Inc., 1444 S. Broadway, Dayton 1, Ohio

Kurz-Kasch
FOR OVER 31 YEARS PLANNERS AND MOULDERS IN PLASTICS

SPEED REDUCERS AVAILABLE

TO BE MADE UP FOR

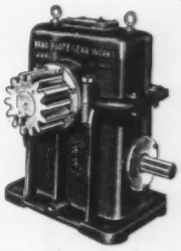
PROMPT DELIVERY

(SOME RATIOS IN STOCK)

WORM GEAR AND GYRO SPEED REDUCERS

Worm Gear Speed Reducers

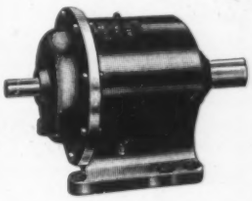
SIZE	QUANTITY	RATIO
3RT	70	5-1/6 to 1
	43	10 to 1
	19	15 to 1
	88	20 to 1
	22	25 to 1
	120	30 to 1
	150	40 to 1
	74	50 to 1
	50	60 to 1
3-3/4HT	5	5-2/5 to 1
	3	7 to 1
	25	10 to 1
	50	14-1/2 to 1
	9	20 to 1
	60	30 to 1
	50	40 to 1
	25	50 to 1
	90	60 to 1
4HT or HA	3	5.8 to 1
	12	10 to 1
	14	16-1/2 to 1
	30	20 to 1
	50	30 to 1
	2	40 to 1
	30	45 to 1
	50	60 to 1



CATALOG 114

OFFERED Subject to Prior Sale

Write for prices and delivery dates



CATALOG 112

Gyro Speed Reducers

SIZE	QUANTITY	RATIO
G-7½	16	24 to 1
	1	30 to 1
	13	40 to 1
	9	50 to 1
	4	56 to 1
	10	60 to 1
	4	80 to 1
	4	100 to 1
	5	120 to 1
	4	200 to 1
	2	408 to 1
	4	480 to 1
G-15	7	30 to 1
	9	40 to 1
	4	50 to 1
	35	60 to 1
	9	81-3/5 to 1
	55	120 to 1
	1	140 to 1
	3	360 to 1
G-25	1	16 to 1
	10	40 to 1
	39	60 to 1
	1	66 to 1
	9	100 to 1
	10	116 to 1
	28	118 to 1
	1	142 to 1
	10	200 to 1
	6	235 to 1
	1	247 to 1
	9	360 to 1
	8	480 to 1
	3	950 to 1
G-40	2	26 to 1
	7	25 to 1
	1	30 to 1
	8	40 to 1
	6	50 to 1
	4	101 to 1
	13	120 to 1
	3	480 to 1
	3	610 to 1
	4	1200 to 1

BRAD-FOOTE GEAR WORKS
1309 SO. CICERO AVE. CICERO, ILL. DEPT. A

To Start · Stop Indicate · Regulate Distant Motion

Where quick, positive control of distant motions is essential, Mall Remote Control Flexible Shafting offers design engineers many important advantages. It simplifies design, saves engineering effort, reduces installation time, conserves labor, and assures precision control. Additional advantages are found in the metallic and elastic plastic housings that insulate the shafting against temperature changes, dampness, dust and corrosion.

Every length of Mall Remote Control Flexible Shafting is designed, engineered and fabricated to fit a specific application such as: opening and closing a skylight or valve . . . regulating a thermostat . . . indicating machine speeds on a tachometer . . . setting hands on a clock and many others where a clockwise or counter-clockwise motion is desired. It can be furnished in almost any length or type with splined, flat, square threaded or other styles of ends made of any desired material.

★Over 26 years of designing, engineering and precision manufacturing experience assures correctness of design and high reliability. Write at once, giving full details of your remote control problem. Our Engineering Staff is at your disposal.

FLEXIBLE SHAFT DIVISION

MALL TOOL COMPANY

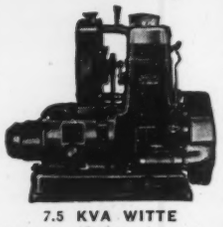
7731 South Chicago Ave., Chicago 19, Illinois

★ *26 Years of "Better Tools for Better Work"*

Mall REG. U.S. PAT. OFF. PORTABLE POWER TOOLS

PROFIT-MAKING POWER FOR INDUSTRIAL MACHINES

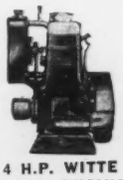
WITTE DIESEL ENGINES and DIESELECTRIC PLANTS



7.5 KVA WITTE DIESELECTRIC PLANT

WITTE Diesel-powered machines can be used everywhere, because of the universal availability and low cost of Diesel fuel oil. Fuel cost savings on WITTE Diesel-powered machines over gasoline-powered machines range up to 75%. Easy to start and operate, WITTE Diesel units occupy small space—keep on giving trouble-free years of service long after earning their original cost. They're built with the same exacting care you apply to the building of your machines.

There's a Vertical or Horizontal Size and Type to Meet Your Auxiliary or Main Power Needs



4 H.P. WITTE DIESEL ENGINE

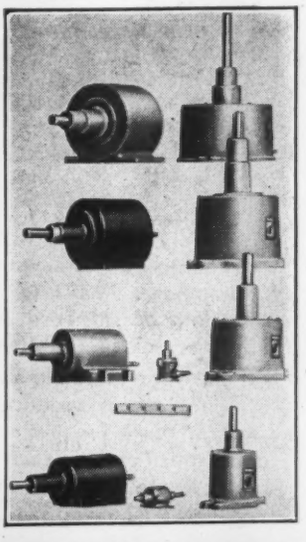
If you are producing such machines as patch rollers, small pumping, welding or air compressor units you will find the ideal power unit for your product in the complete WITTE Diesel line. Write today for new WITTE Catalog No. 11, showing typical applications of WITTE Diesel Engines and Dieselectric Plants around the world. Mass production of WITTE Diesel Engines from 4 to 12 H.P. and Dieselectrics from 3 to 10 KVA assures early deliveries.

WITTE ENGINE WORKS

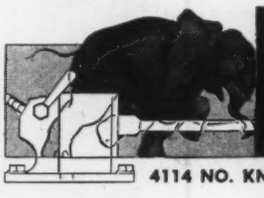
DIVISION OF OIL WELL SUPPLY COMPANY — UNITED STATES STEEL CORPORATION SUBSIDIARY

AMERICA'S PIONEER BUILDER OF SMALL DIESELS — KANSAS CITY 3, MO., U.S.A.

I save Time, Worry and Production Costs by using these MEAD AIR CYLINDERS



These simple, adaptable, single-acting Mead Air Cylinders will solve your work-holding problems quickly, economically! Available in numerous vertical or horizontal mountings and in a wide range of sizes all featuring spring-return action. Write for new Mead Air Power Catalog describing single and double acting Cylinders, Valves, Presses, Clamps, Work Feeders, Vises, Impact Hammers, Collet Fixtures and other air-operated devices.



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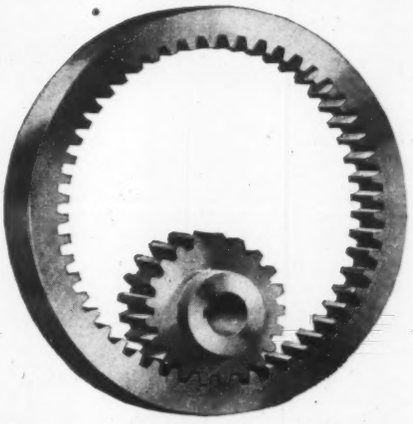
"Industrial"

CUT GEARING — ALL TYPES AND MATERIALS
ROLLER AND SILENT CHAIN SPROCKETS



INTERNAL GEARS

MAKE IT A HABIT TO SEND US YOUR ORDERS

INDUSTRIAL GEAR MFG. CO.
4529 VAN BUREN STREET CHICAGO 24, ILLINOIS

JONES 300 SERIES
PLUGS AND SOCKETS

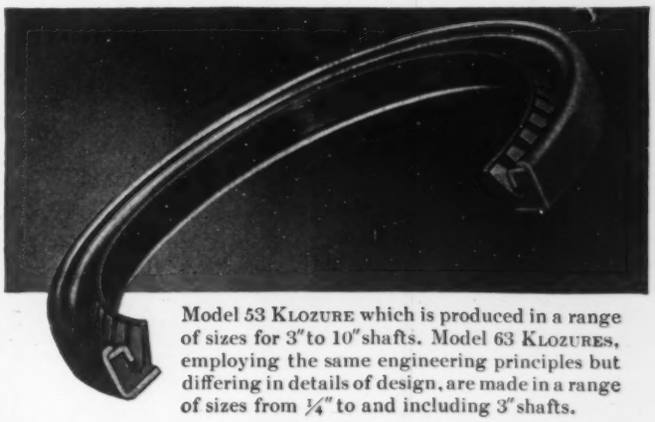
P-306-CCT

S-306-AB

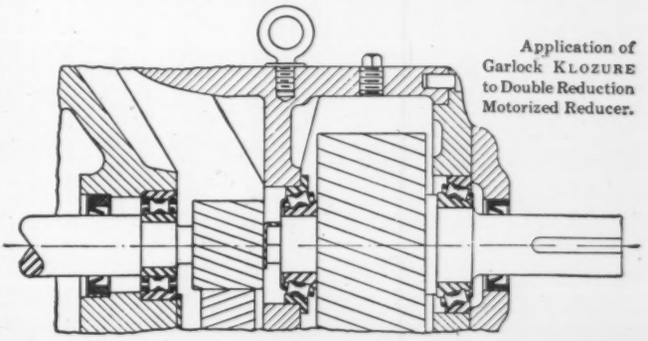
A high quality line of small Plugs and Sockets adaptable to a thousand uses. All Plugs and Sockets are Polarized. "Knife-switch" Socket contacts are of phosphor bronze, cadmium plated. Bar type Plug contacts are of brass, silver plated, with a cross section of 5/32" by 3/64". Insulation is of BM 120 molded Bakelite. Caps are of metal with formed fibre linings. Made in 2 to 33 contacts. Although designed for 45 volts at 5 amperes, these Plugs and Sockets can be used at considerably higher ratings where circuit characteristics permit.

For complete information write today for catalog No. 14 showing the Jones line of Electrical Connecting Devices—Plugs, Sockets, Terminal Strips.

HOWARD B. JONES DIVISION
CINCH MFG. CORP.
2460 W. GEORGE ST. CHICAGO 18



Model 53 KLOZURE which is produced in a range of sizes for 3" to 10" shafts. Model 63 KLOZURES, employing the same engineering principles but differing in details of design, are made in a range of sizes from ¼" to and including 3" shafts.



Application of Garlock KLOZURE to Double Reduction Motorized Reducer.

KLOZURE Oil Seals
Models 53 and 63

Extreme sensitivity and flexibility of these new Models 53 and 63 KLOZURES reduce friction to a minimum and provide an efficient seal even on shafts having considerable "whip" or lateral movement. They give superior performance on high or low shaft speeds. For use under various operating conditions and on many different kinds of equipment. Write for new catalog.

THE GARLOCK PACKING COMPANY
PALMYRA, N. Y.
In Canada: The Garlock Packing Company of Canada Ltd., Montreal, Que.
60th Anniversary 1887—1947

GARLOCK
Klozure
OIL SEAL

A HABIT TO JOE...

"NEW IDEA" TO HIS NEPHEW

...YET BOTH WANT THE SECURITY your P.S. Plan Provides

HAVE YOU told all your new or recently hired employees about the benefits of the Payroll Savings Plan for the regular purchase of U. S. Savings Bonds? Wage earners, according to a recent nation-wide survey, want security more than anything else. They prefer security to big pay, soft jobs, authority, "success."

There is no surer way to this peace of mind than systematic savings. And what surer, safer, better means can your employees find than payroll allotments for U. S. Savings Bonds? Bonds that return $4 at maturity for every $3 they invest!

Your active support of the Payroll Savings Plan is an investment in employee contentment, in the citizenship of your community, and in the security of America's future. This is practical "employee relations" of the highest type and pays dividends of satisfaction to everyone.

Start a drive today for larger participation in the plan. Many employees may be unfamiliar with its advantages. If you want literature for distribution, contact your State Director of the Treasury Department's Savings Bonds Division.

New Savings Bonds Plan won't affect the P.S.P.

THE Treasury Department and the banks of America are making it possible for farmers, doctors, and other self-employed people to participate in "automatic" Bond buying by special arrangement with their banks. This extension of the Savings Bonds program is not a partial payment plan and is intended *only* for people who are not in a position to take advantage of the Payroll Savings Plan.

The Treasury Department acknowledges with appreciation the publication of this message by

MACHINE DESIGN

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"O" RING PACKINGS

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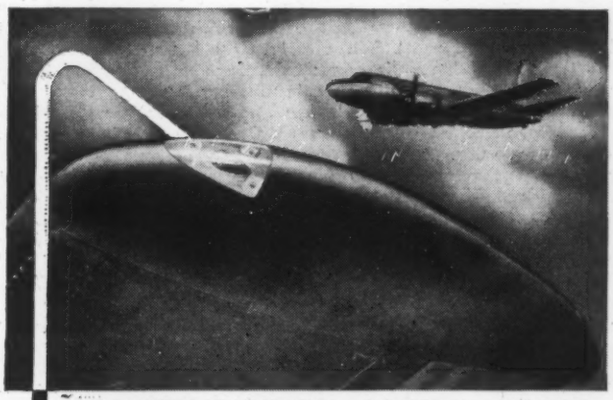
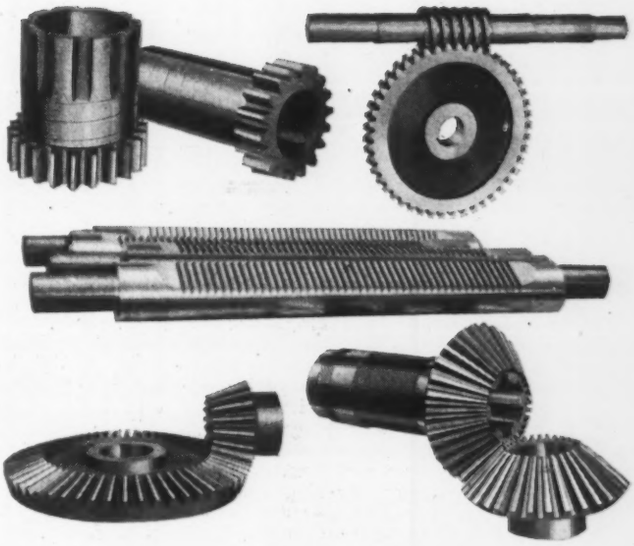


***this* NAVIGATION LIGHT COVER**
has all the answers

When engineers of the Glenn L. Martin Company designed the wing-tip navigation light (above) for the new Martin 2-0-2 twin-engined airliners they specified that covers must fit flush with the wing edge, forming part of the wing contour. That meant complex curves and accurate fit. It also meant precise machining of three plastic support blocks to conform to the cover contour. It necessitated really permanent cementing of these curved surfaces. It entailed precision drilling of bolt-holes for attaching. Fabri-Form met these difficult requirements. If you have a plastics fabrication problem involving sheets, rods or tubes, put Fabri-Form "know-how" to work on it. Just tell us about it; we'll tell you the cheapest and best way to do it. We know how.

THE *Fabri-Form* CO.
108 Seneca St. Byesville, Ohio



Skilled Gear Craftsmen
Modern Gear Cutting Machines
. . . build quality and dependability into every

ADAMS GEAR

It takes experienced men and fine machines to make really good gears—Adams has both. In addition, Adams gears are quality controlled at every stage in their manufacture to assure exact conformance with your specifications. This extra care means better performance for your product. And in many cases, custom made gears, designed especially for the application will cut assembly time and lower unit costs. Write for complete information, today.

THE ADAMS COMPANY
1942 Tower St., Dubuque, Iowa

The ADAMS Line

Spur Gears	Splined Shafts
Helical Gears	Racks
Bevel and Miter Gears	Lead and Feed Screws
Worms and Worm Gears	Ground Tooth Gears (spur and helical)
Internal Gears (spur and helical)	Shaved Tooth Gears (spur and helical)
Sprockets	Ground Thread Worms
Ratchets	

The ADAMS Compa
Dubuque, Iowa, U. S. A.
ESTABLISHED 1883
FINE GEARS MADE TO YOUR SPECIFICATIONS

GEARS

ENGINEERS
AVAILABLE OR WANTED

AVAILABLE: Licensed mechanical engineer with 25 years experience wishes to organize or manage existing organization to make economic studies and design special purpose equipment and automatic machinery. Adress Box 559, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

UNUSUAL OPPORTUNITY for experienced men who have a real record in mass production. Interested in becoming permanently affiliated with progressive, substantial manufacturer of internal combustion engines, having approximately 900 employees. Permanent positions open for: 1. Assistant to president—engineering and production training preferred. 2. Chief engineer—must be good administrator and take charge of engineering department. 3. Assistant chief engineer. 4. Draftsmen layout and detail men. 5. Heat treater—must be capable of running carburizing plant also heat treating stressed aluminum castings. 6. Machine shop superintendent—for high production plant. 7. Specifications engineer—familiar with gasoline engines. Existing executives being promoted as expansion gets under way. If you consider yourself top-flight talent, and can qualify for any of the above positions, and are interested in being rewarded for hard work and application in a Mid-West location, write Box 557, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

WANTED—Engineer. Rochester, New York industry offers excellent opportunity to graduate M.E. or E.E. engineer, 28-38 years of age, experienced in over all responsibility for design on small precision mechanical devices from inception to production drawing stages. Must be able to make own design layout. Reply should give complete details. Address Box 556, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

WANTED: Mechanical engineer. Must have technical education and experience in design and development of heavy material handling equipment as Ore Bridges and Cranes. Must be capable of rapid accurate work under general supervision only. Reply by letter only giving all relevant details as to age, education, positions held, design achievements, etc. Work located in the Pittsburgh, Pennsylvania, district. Address Box 554, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

WANTED: Development engineer required by Midwest manufacturer of thermoplastic films, to work with the trade and in our laboratories in adaptation of packaging machinery to use our products. Also, mechanical engineer, 25-40, preferably with packaging machinery experience and with a pleasant personality. Will receive salary commensurate with ability. A considerable amount of travel will be required. Please include complete employment, educational and achievement record in initial. Address Box 555, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

WANTED: Designers for home appliances. The engineering department of the Hoover Company, world-wide manufacturer of home appliances, fractional horsepower motors and commercial die castings, invites correspondence with experienced and capable mechanical designers interested in a position with a company with an assured future. Design experience on home appliances desirable but experience on other mass-produced mechanical devices may be suitable. Engineering college graduates preferred, but this is not an essential requirement. Design problems encompass use of die castings, compression and injection plastic and rubber moldings, metal stampings and other manufacturing process. Complete laboratory and experimental shop facilities of a research and development group, numbering over 130 people available to supplement designers' work. Interviews may be arranged. Address reply to the Hoover Company, Attention: Executive Engineering, North Canton, Ohio.

WANTED: Outstanding technical men. Mechanical or aeronautical engineers experienced in heat transfer, thermodynamics, engine design aerodynamics, stress analysis, mathematical analysis. Also, metallurgical and ceramic engineers experienced in powder metallurgy, ceramic bodies and coatings. This new field offers unusual opportunities for outstanding men who are interested in becoming associated at the beginning of a project offering unlimited possibilities in nuclear and aeronautical engineering. If interested, please furnish resume giving personal, educational, and experience data to Nepa Division, Fairchild Engine & Airplane Corporation, P. O. Box 415, Oak Ridge, Tennessee.

WANTED: Marine engineer. Must have technical education and experience in design and development of tugs, dredges, etc. for inland river operations. Propeller design experience also required. Must be capable of rapid and accurate work under general supervision. Reply by letter only giving all relevant details as to age, education, position held, design achievements etc. Work located in the Pittsburgh, Pennsylvania district. Address Box 558, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

WANTED: Mechanical engineers and designers. The Collins Radio Company of Cedar Rapids, Iowa, has always been a pioneering organization—an engineer's engineering and manufacturing concern. It was this urge that has finally led us to be among the leading manufacturers of high-quality broadcast equipment and to meet the individual requirements of some of the great airlines with especially engineered communication equipment, including the ingenious Collins Autotune—the result of research and development looking years ahead. We are looking far ahead today in the field of qualiy radio communications and other electronic equipment. Our plans, well advanced, offer substantial opportunity for mechanical design engineers in a field of interest, research and development. Cedar Rapids is a human, wholesome city. People enjoy living here and working in our modern plant, which is neither small nor large, but rather ideal. If you feel qualified for one of these positions, write us fully, stating age, education and experience, as well as other pertinent data you feel might assist us in fully and promptly considering your application. All replies will be held strictly confidential. Apply to Collins Radio Company, Cedar Rapids, Iowa.

WANTED: Designer. Head designer for automatic machinery. Outstanding opportunity for an experienced designer with engineering degree or equivalent. Must be experienced in automatic machinery development work and be capable of, and interested in, assuming supervisory and administrative functions. Location suburban Philadelphia. Company is nationally known. Consumer goods manufacturer and offers an assured and interesting future with excellent working conditions. Retirement and stock purchase plan. Please furnish complete personal and working record and recent photograph (not returnable). G-50, P. O. Box 3552, Philadelphia 22, Pennsylvania.

WANTED: Exceptional opening for sales engineer to cover Mid-West metalworking industry. Selling experience desirable but not essential. Nationally known manufacturer of production material wants man to advise customers on applications—not take orders—working in Michigan and Indiana, with headquarters preferably in Detroit area. Salary to be commensurate with experience. Requirements: Varied knowledge of metalworking production gained by plant work or selling; ability to travel extensively away from home. Write in detail about background. Interview arranged at New York headquarters; expenses paid. Address Box 553, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

Nothing CAN DAMAGE EXPENSIVE CONTROL EQUIPMENT ANY *Quicker* THAN A BIT OF *Foreign Material* in the PIPE LINE

Protect that equipment by the installation of a good sturdy strainer in the line just ahead of the equipment.

The new CASH-ACME "Y" Type Strainers are ruggedly built around 250 pounds cast iron standards.

BRASS OR CAST IRON BODIES AVAILABLE.

⅛" TO 2" PIPE SIZES.

STANDARD OR SPECIAL SCREENS.

STOCK-CATALOG-SELL CASH-ACME Products

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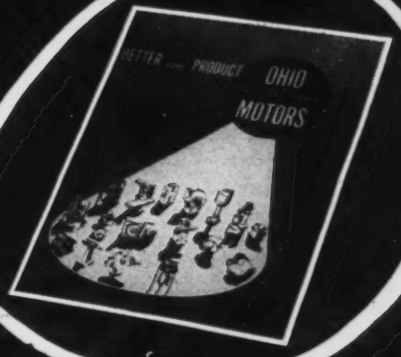

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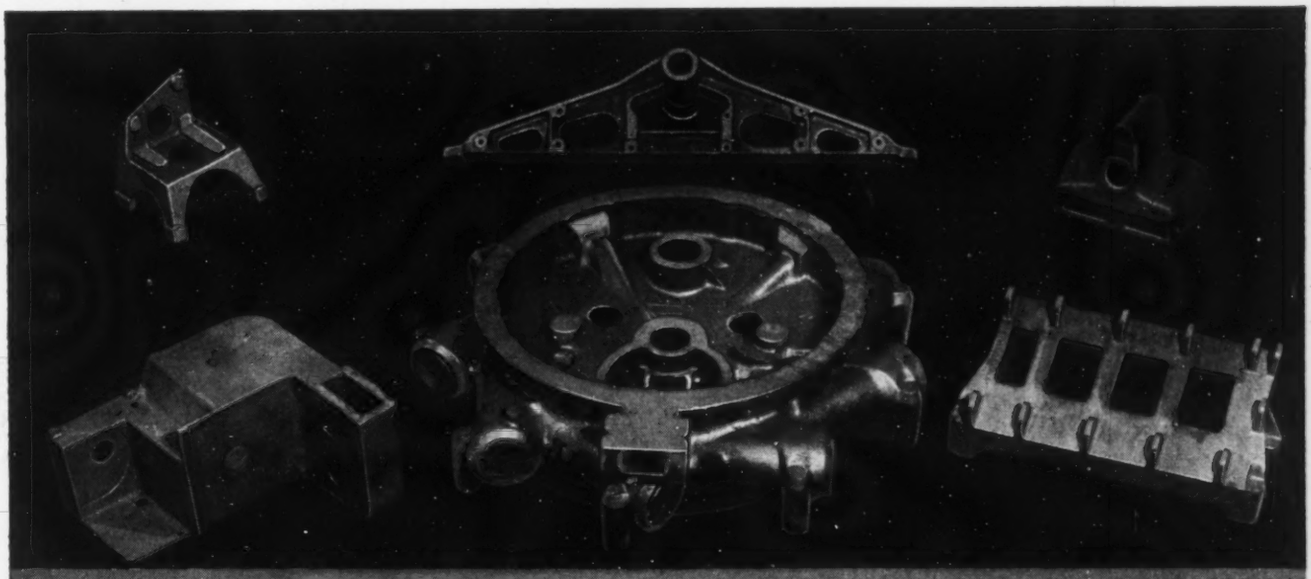

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Drive five shafts: 2 clockwise, 3 counter-clockwise.

The Solution:

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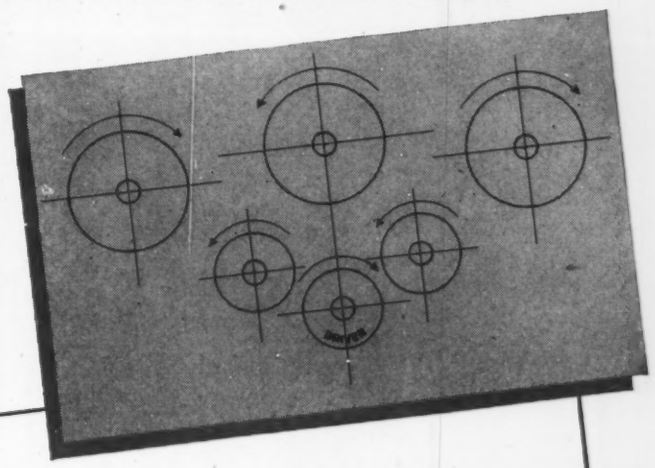

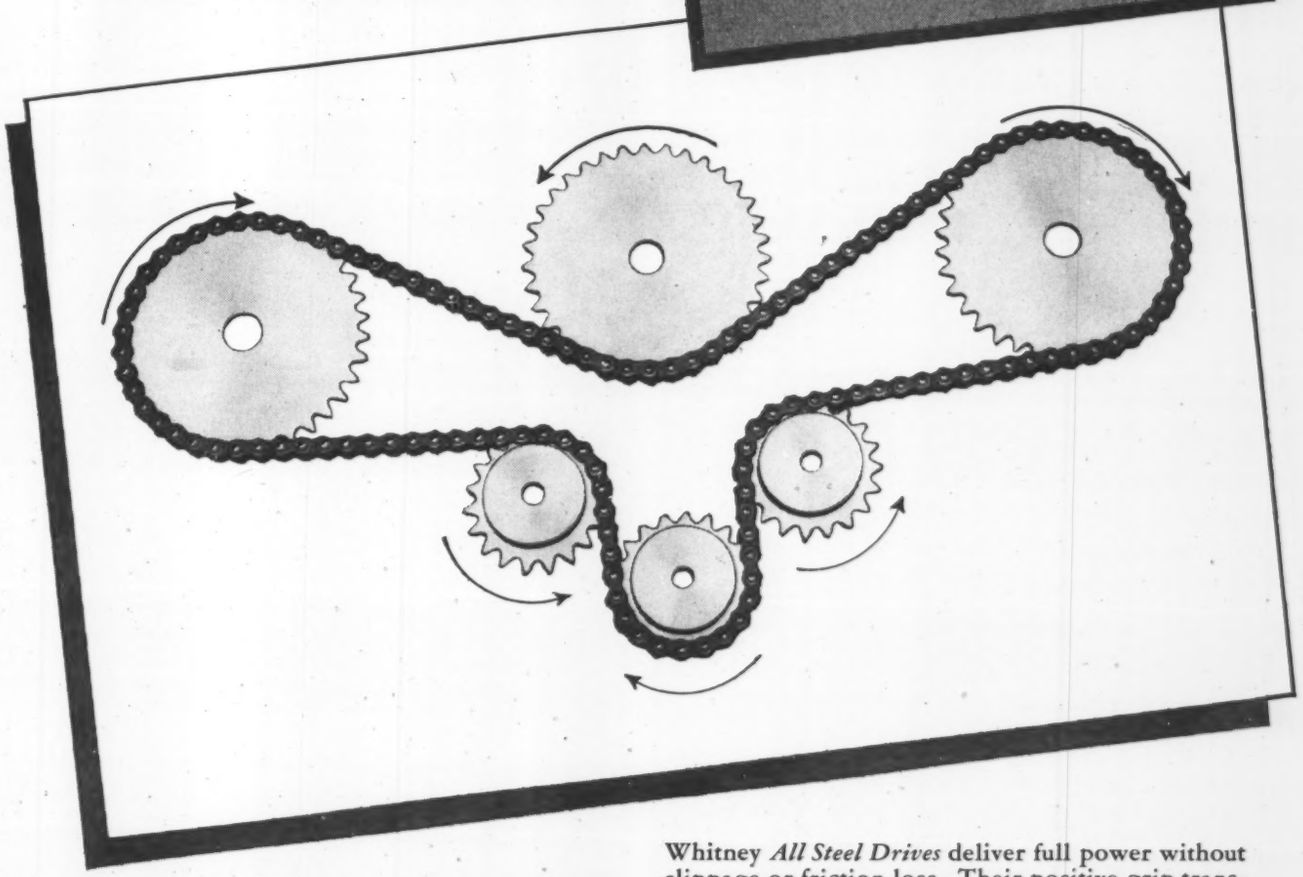

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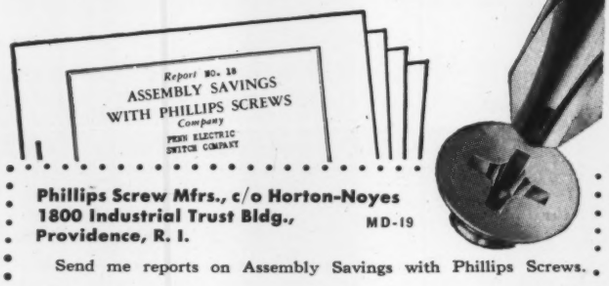

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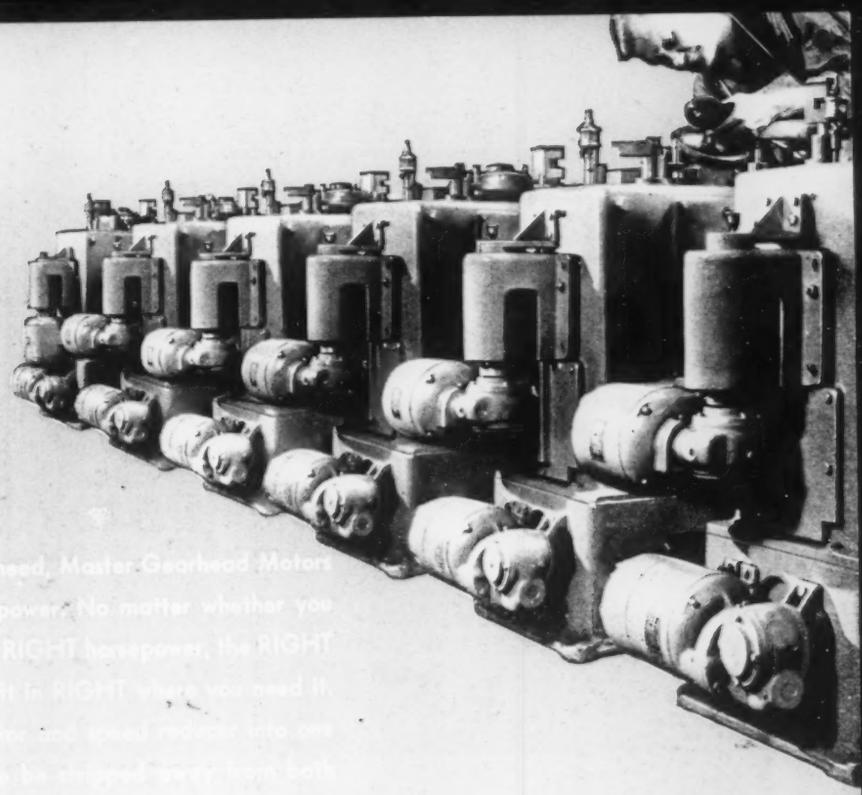

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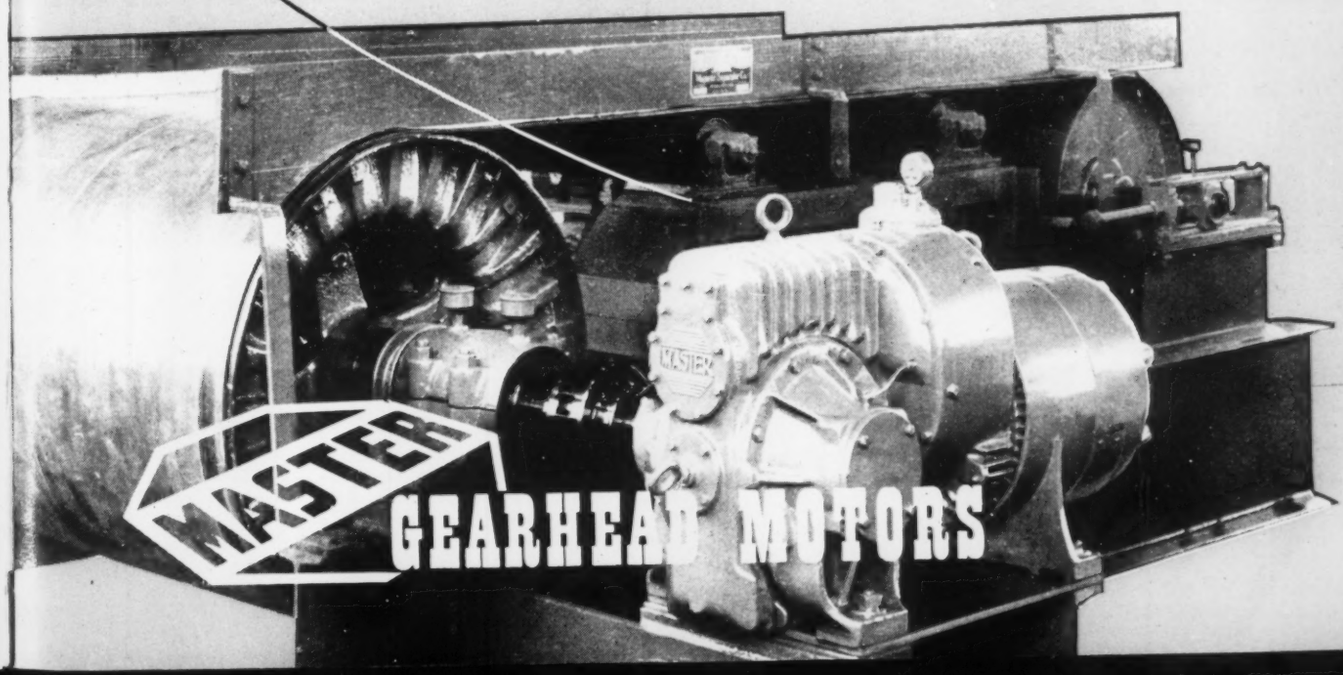

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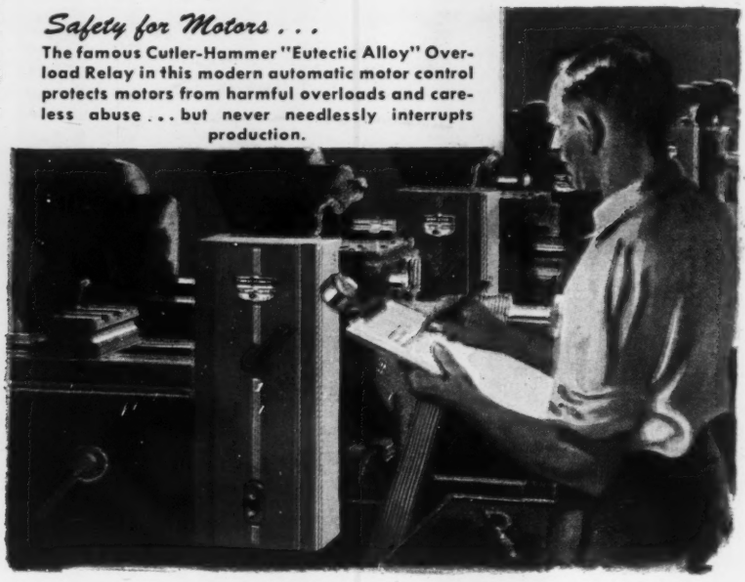

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